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A
DISSERTATION
ON
NATURAL AND SUSPENDED
RESPIRATION.

By EDWARD COLEMAN,

PROFESSOR OF THE VETERINARY COLLEGE,
VETERINARY SURGEON GENERAL TO HIS MAJESTY'S
CAVALRY, AND MOST HONOURABLE BOARD
OF ORDNANCE, &c.

SECOND EDITION.

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1802.

RESPIRATION

ON

NATURAL AND ARTIFICIAL

RESPIRATION

BY EDWARD COLEMAN

PROFESSOR OF THE PHYSIC IN THE UNIVERSITY OF CAMBRIDGE

WITH A PREFACE BY THE REV. J. J. WOOD, D.D.,
CHAPLAIN OF THE UNIVERSITY OF CAMBRIDGE



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1852

DEDICATION.

To HENRY CLINE, Esq.

LECTURER ON ANATOMY, AND SURGEON
TO ST. THOMAS'S HOSPITAL.

DEAR SIR,

THAT distinguished eminence you have so deservedly attained in the medical world, and that gratitude you might so justly claim from all your pupils, particularly from one who is indebted for his surgical and physiological knowledge, not only to your public but private instructions;

DEDICATION.

structions; would alone prove sufficient inducements for me to address these first-fruits of my professional studies to you.

But, however powerful these motives, allow me to add, there is another yet more cogent, and which flows more immediately from the heart—

That friendship with which you honoured me while resident under your roof, and which you have kindly continued since I quitted that hospitable mansion, to enter the busy scenes of life, will for ever live in my recollection, and awake the most grateful emotions of a feeling mind.

Permit me then to hope you will receive this Dedication as a small but sincere testimony of that sense I entertain of
your

DEDICATION.

your esteem ; to merit and to enjoy which,
to the latest period of my existence, is the
highest ambition of,

Dear Sir,

your much obliged

and most humble servant,

EDWARD COLEMAN.

Veterinary College.

April 20, 1802.

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INTRODUCTION.

INTRODUCTION.

OF all the exertions of human skill, there is, perhaps, none which affords more solid and lasting gratification, than the restoring to life those who are apparently dead; none, surely, more eminently shews the dignity and fruitfulness of Philosophy, or more clearly evinces the benefits that may be derived from the well-directed efforts of human understanding.

This art (if such it might be called in so rude a condition) was, in former ages, guided chiefly by blind prejudice; the knowledge of the animal œconomy, and of life, was not sufficiently extended, to afford maxims of any value to the prac-

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titioner; and the causes of death were too incorrectly marked, to shew, with any degree of precision, the means of recovery.

Accidental recoveries had, indeed, shewn that it was practicable; but Physiological science was unable to explain or prescribe the mode. It was reserved for the eighteenth century, to exhibit, on a large scale, any practical specimens of this mode of benevolence, and to approach, in some respect, to the scientific solution of those principles by which it must be guided. Many societies were formed on the continent of Europe, for the purpose of promoting this kind of knowledge; and their reports afforded the most mortifying reply to those who had declaimed with such triumph on the vanity of natural science, and the impotence of human art. Their multiplied successes, in so untried a path, awakened a
general

general ardour on this subject, which was not a little fostered by a cotemporary improvement in natural knowledge: I allude to the philosophy of elastic fluids, which has, during the last part of the present century, received such incredible accessions. The doctrine of *airs* was so intimately connected with the subject of respiration, that it could not fail to fix the attention of Philosophers on those cases where its sudden suspension was the cause of death. It were superfluous to enumerate the various theories offered by the Chymists and Physiologists of this recent period. Suffice it to remark, that the Humane Society of London deemed the subject so perplexed with discordant theories, and so susceptible of farther experimental elucidation, that they published, in 1787, a question on *the nature of the diseases produced by submersion, suspension, and noxious airs*. Two dissertations,

tations, of peculiar merit, they honoured with prizes : those of Dr. Goodwyn and Mr. Kite. The same enlightened and benevolent body pursued this inquiry, by proposing a question—“ *Whether Emetics, Venesection, or Electricity, be proper in suspended Animation, and under what Circumstances ?*”

To this question, I am about, in the following Dissertation, to attempt an answer. It may be thought, that, as this question is purely *practical*, any investigation of the *proximate cause* of the malady is superfluous and impertinent, and that our views ought to be limited to the remedies employed in its cure ; or it may, perhaps, be supposed, that such inquiry is precluded by the successful labours of Dr. Goodwyn and Mr. Kite : but reason, which forbids us to abandon
any

any thing so important to blind empiricism; the example of these Gentlemen, who had from their pathology deduced their cure, and the repugnance of their inferences to each other, which countenanced a doubt respecting the accuracy of either,—seemed to prove the necessity of reinvestigating, by experiment, the nature and causes of the disease, previous to the delineation of any plan of cure. One of these Gentlemen attributes death in these cases to the quality of the blood in the left side of the heart, which has not received from the air, that stimulant power which supports the action of that organ. The other attributes it to apoplexy. I was induced, since the appearance of these essays, to attempt a series of experiments on the subject, which perhaps I should not have cultivated with so much ardour, had I not been animated by the example

of Mr. Kite, from whom I received the rudiments of my medical education, and for whom, in combating his opinions, I trust I shall not be deficient in that respect which his talents demand. These experiments presented results which contradicted, in many important particulars, received opinions: but I should not, at so early a period of my life, have presumed to offer them to the public, had I not been emboldened by the approbation of the Medical Society of London, who voted me the Humane Society's Medal.

Dr. Goodwyn has justly and ingeniously remarked, that the expression, "Suspended Animation," is objectionable. Respiration and circulation may be suspended; but the principle of life, or the susceptibility of action, which is the source of these functions, may still remain. Life, there-
6 fore,

fore, can with no propriety be said to be suspended, when the vital principle is present. The animal must either retain the principle of life, or be absolutely and irrecoverably dead. There is no intermediate state between life and death. The distinction between the actions and powers of life, which, with so many other admirable observations in Physiology, we owe to the ingenious Mr. Hunter, clearly illustrates the impropriety of the language to which we object. He has proved that in many cases, these powers remain when the actions are suspended. The presence of these powers alone constitutes life, and forms the sole distinction between inanimate and animated matter. When they cease to be present, life is *not suspended, but destroyed*. Instead therefore of employing the term Suspended Animation, we shall adopt that of *suspended*

B 4 *respiration,*

respiration, which only simply expresses a fact, and is equally applicable to those cases which terminate in death, as to those of which the event is favourable.

The necessity of inflicting a painful death on so many animals will ever be felt by minds of sensibility, as a cruel alloy to the pleasure of Physiological research. By no other mode, however, than that of experiments on living animals, can any important advance be made in this subject. Such experiments, in a question of mere curiosity, are certainly indefensible; but where, as in the present case, the advancement of truth conspires with the interest of humanity, we must impose silence for a while on the remonstrances of sensibility.

In the conduct of the experiments
which

which form the basis of the following dissertation the most solicitous accuracy has been every where studiously sought.

To those who are in the habits of Physiological experiment, nothing is more familiar than the perplexing variety and repugnance of their results; two experiments, though made in the same manner on the same order of animals, will rarely in every particular agree; for it is not only true, that different species of animals, but that different individuals of the same species, possess various degrees of irritability. In some, irritability may be excited for several hours after apparent death, others lose it in less than one. The cause, however, of these variations, where they have been in any respect considerable, we have generally discovered to be some accidental and extrinsic circumstance, and by multiplying
and

and varying experiment, we have attempted to discriminate between what is made the foundation of *general* principles, and what is the effect of peculiar and fortuitous circumstances. But the enthusiasm which we acquire in the pursuit of a favourite research, and our anxiety to support a cherished opinion, ought ever to make the experimental inquirer diffident of the correctness and impartiality of his *own* views. A bias unconsciously taints his judgment, against which the only remedy is, the vigilant eye of acute and intelligent friends, who feel more anxiety for his reputation, than tenderness for his prejudices; and who have no motives either to make tortured inferences, or to hide unfavourable results.

The same good fortune that has blessed my private life with the friendship of such men, I have also eminently felt in my
scientific

scientific pursuits. Their acuteness has rescued me from my prejudices; and their aid has given me a confidence in the correctness of the experiments, which distrust in my own individual skill would otherwise never have permitted me to entertain. I have to mention with particular gratitude, Mr. Astley Cooper, whose anatomical and physiological knowledge needs no comment; and Mr. Keir, a gentleman of distinguished ingenuity, who favoured me with his occasional assistance. And it affords me no small gratification, that my much respected friend, Dr. Haighton, Teacher of Physiology, in the Borough, has made many experiments which corroborate most of the opinions here advanced.

Though submersion be the most frequent, it is by no means the only case of
apparent

apparent death worthy the inquiry of the Physiologist, or the attention of the medical practitioner. Nor is the benevolent zeal of the Humane Society confined to it alone; as every case of apparent death, arising from a sudden suspension of respiration, partakes equally of its bounty; and indeed, agreeable to this extensive view of the subject, the question before us is proposed.

The suspension of vital action from strangulation and noxious airs exhibits phænomena so nearly similar, and requires a treatment so strictly congenial, that any inquiry into the nature of submersion would be narrow and imperfect, unless illustrated by the investigation of these kindred diseases. To them, therefore, we have thought it expedient to extend our researches; and from inductions founded
on

on a series of experiments and observations on these different modes of death, we flatter ourselves with the hope of having established a general doctrine on premises less ambiguous and unstable, than those which have been the basis of former theories.

To ascertain phænomena is the first duty of every inquirer into nature. We shall, therefore, preface any inquiry into the nature of suspended breathing, by the Physiology of the organs which are its seat; thus delineating their natural actions, before we examine their morbid condition. The Physiology of the heart and lungs therefore will constitute our first section.

We shall then proceed to describe the
phænomena

phænomena of departing life, the appearances on dissection, and to consider that peculiar condition of the animal which forms the *proximate cause* of the disease.

The remaining part, to which the preceding sections are but preliminary, will be devoted to the consideration of the cure: and in order to investigate more at length the efficacy of those means which have been either suggested by speculation, or sanctioned by experience, we shall dedicate a section to each class; by which we shall be enabled to form a just estimate of their comparative efficacy and importance.

Emetics, Venesection, Electricity alone
or combined with artificial Respiration,
Warmth,

INTRODUCTION. 15

Warmth, Frictions, and Clysters, will be fairly examined by the tests of experiment and of reason; and our last section will consist of conclusions drawn from the whole.

SECTION

SECTION I.

Physiology of the Heart and Lungs.

IT is by no means my design to extend this investigation to every advantage that results from respiration, as the voice, smell, &c. but merely to take a superficial survey of those functions more immediately connected with *life*.

On this subject Dr. Goodwyn has bestowed no small share of attention; and though the result of my observations does not permit me to yield assent to many of his opinions, yet the resources of his ingenuity and perspicuity of arrangement must ever claim admiration and applause.

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But before we inquire into that particular connexion which subsists between breathing and life, our first object is briefly to consider the manner in which respiration is performed in health.

The expansion of the thorax in ordinary inspiration is effected by the intercostal and other muscles, and its cavity lengthened by the descent of the diaphragm; but in laborious inspiration, the *serratus major anticus*, *pectorales*, &c. bear a considerable part.

Expiration is said to be both an active and passive process: it is active when the abdominal muscles compress the viscera, and draw the ribs downward and backward, or in quadrupeds upward; and passive, from some of the muscles of inspiration at this time relaxing.

The

The lungs themselves are somewhat elastic; but are passive in respiration. They may not unfitly be compared to a pair of bellows, and the muscles of respiration to the power that works them. In their state of expansion, or when the muscles of inspiration act, the cavity of the chest is enlarged; but when compressed, by the action of the muscles of expiration, the cavity is lessened and the air expelled. Thus, by this alternate dilatation and contraction of the thorax, the process of respiration is supported.

The action of these muscles in a state of health is involuntary, and is less influenced by the will than most of the other muscles in the body : we are able, however, for a short interval, to check or increase their action, but that it should not be wholly subservient to the will, is very wisely ordained ; for

otherwise the powers of respiration must cease whenever the senses are suspended by sleep or insanity.

It has been generally supposed that one of the natural functions annexed to the lungs was that of assisting, by their alternate dilatation and contraction, in propelling the blood from the right to the left side of the heart; but in health they seem to possess no such power; for if circulation depended on their mechanical action, suspending the breath for one twentieth part of a minute would produce a cessation of the heart's motion, and the heart of the human subject would then have but one pulsation to one expiration, whereas in health we have four. Some animals have six pulsations to one expiration; the horse in ordinary breathing has only two.

It

It is therefore very probable, that the pulsation of the heart is not governed by the action of the lungs in natural respiration; and from an experiment in the next section it will appear that the right side of the heart, unassisted by the action of the lungs, is capable of sending blood to the left, even after the respiration has ceased. If then the heart, in a state of debility, can perform this function independent of the lungs, can it be supposed unequal to it in the vigour of health? Groundless therefore is the supposition that attributes this office to the lungs in ordinary respiration.

But a subject more delicate and abstruse, a subject that of late years has been warmly and ably controverted, now claims our attention; I mean the alteration induced on the blood in the lungs; the cause on which

this alteration depends; and the effect it produces on the animal œconomy.

To investigate the peculiar change which the air may undergo in the lungs, is not of much consequence to our present inquiry; but before we can obtain any knowledge of the *proximate cause* of death in suspended respiration, it is absolutely necessary to trace and ascertain the effects produced by the air on the blood.

We are inclined to the opinion of the late celebrated Dr. Crawford, that a principal advantage derived from respiration is *animal heat*; that when the blood returns from all parts of the body to the lungs, it has lost a quantity of its latent heat*, and imbibed some

* According to Locke's definition, heat is a sensible quality; and if this definition be admitted, then, properly speaking, there can be no such thing as latent heat, as
that

some noxious quality; that in the lungs it meets with atmospheric air, containing a portion of oxygene, which is known to possess heat in a latent form; that it absorbs part of this heat, and at the same time imparts to the air which remains its impurity.

That the blood having thus robbed the air contained in the lungs of a portion of its latent heat, and rendered that which remained sensibly warm, the air is expelled, and fresh air taken in to undergo a similar process.

Dr. Crawford, in the course of his experiments, had occasion to observe that animals immersed in a warm, did not so soon con-

that must cease to be heat when once it becomes insensible; but as the term appears to convey the idea we wish, that of a principle or quality existing in a body which cannot be measured, but under certain circumstances can produce sensible heat, we have preferred it to others.

sume a given quantity of oxygene as those immersed in a cold medium: nor is the reason inevident; for when the blood arrived at the lungs, it had not lost so much of its temperature, consequently did not require to rob the air of so much of its purity; whereas, in the other case, the animals being immersed in the cold medium, were obliged to generate more heat: but to effect this, they must absorb a greater quantity of oxygene than those in the warm medium. It is also observed, by the same author, that the difference between the colour of the venous and arterial blood was diminished by exposing animals to heat, and increased by exposing them to cold.

The object of these experiments was to prove, that in proportion as the atmosphere is cold, more or less fire is absorbed from the air, to keep up an equilibrium of heat;
and

and it is remarkable that the animal in the warm medium died first, notwithstanding the blood was florid, and the surrounding air more pure than that which the animal breathed when in the cold medium.

The one dying sooner than the other probably depended on debility; that the one in the warm medium, from being obliged to generate cold, or more properly *resist heat*, was rendered weaker than the other, from this process being more expensive to the system than generating heat; for there appears such a tonic power in cold, that an animal will allow of its natural heat being diminished several degrees without inconvenience, but cannot suffer its sensible heat to be increased more than six degrees at most of Fahrenheit, without death taking place. Hence it would seem that although the fluids of the one contained more of the
stimulating

stimulating quality than the other, yet from the solids not being so susceptible of action, life could not continue so long: and it appears probable, that if the animal in the cold medium could have exchanged its blood with that in the warm one, the difference in the duration of life would have been still greater.

The objections adduced against Dr. Crawford's truly ingenious theory seem to possess but little weight. It is urged by some, that if breathing be the source of animal heat, how can it happen that the inhabitants of the northern climates breathe no quicker than those of the southern; and yet nearly the same degree of animal heat is present in both? The reason appears obvious; there is always existing in the atmosphere a much greater proportion of oxygene than is consumed by any animal
in

in one inspiration; so that those in the colder climates, although they breathe no quicker, nor take in a larger volume of air, yet they rob that air of more of its latent fire.

The cold atmosphere, bulk for bulk, must be specifically heavier than the warm, and, weight for weight, the bulk will be less; so that any given quantity of air, in proportion as the temperature is diminished, its volume must decrease; and vice versa. Hence in a cold atmosphere, although the volume of air taken in at each inspiration be the same, yet in that volume a greater number of particles of air are received into the lungs; and it also seems probable, that, weight for weight, this atmosphere should contain more oxygene than the warmer, since it is generally allowed that in proportion as its warmth is increased, it becomes a
better

better menſtrum for foreign matter of all kinds.

Dr. Crawford ſuppoſed that heat is given out in the capillaries only; but there is reaſon to believe that heat is alſo evolved during the whole of the circulation; for in amputating a limb, where the tourniquet has been for ſome time applied, the firſt blood iſſuing from an artery aſſumes a venous colour; and Mr. Hunter found, from tying up the carotid artery of an animal, that the blood became black; from which it may be concluded that the blood is capable of undergoing the ſame proceſs in the larger arteries as in the ſmaller veſſels. In ordinary circulation, however, the change muſt be leſs in degree, from the circulation being here quicker, and a greater quantity of blood being in contact with fewer ſolids.

It

It seems also more than probable that the blood still retains a quantity of fire in a latent form after it has passed through the capillaries and entered the veins; for, on applying pressure to a vein in common bleeding, the longer a ligature is applied the darker the blood becomes; and at the conclusion of the operation its colour assumes nearly a florid hue; which corroborates the opinion that it may possess a considerable portion of the latent principle after it has entered the veins; and that this blood is capable of continuing the same process, so long as it contains any heat to evolve. In fever, the venous blood is sometimes nearly florid; and Dr. Crawford found that when animals were immersed in a warm medium, the blood passed through the capillaries without undergoing the usual change: both which circumstances tend to prove, that the blood contains more or less of that principle absorbed

forbed in the lungs after it has entered the veins; indeed, the circulation in fishes appears to decide the question, for the heart of these animals is a single one, consisting of one auricle and one ventricle, both of which contract from the stimulus of black blood; and as the blood in the coronary vessels is of the same quality, its heat and nourishment must be kept up by that blood only which has passed through the capillaries.

Hence it appears, that if this black blood did not possess a quantity of latent fire, the warmth and life of the heart could not be supported: notwithstanding, therefore, that the blood, when it passes through the capillaries, evolves the greatest part of its heat, yet there still remains a portion of it in a latent state even after it has entered the right side of the heart: and however inconsiderable this may be, yet if it is equal to
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the demand, the temperature of the whole animal must be the same. With a view to ascertain the comparative temperature of arterial and venous blood the following experiment was made.

EXPERIMENT.

A Dog was hanged, the sternum immediately removed, and the lungs inflated until the blood in the left auricle became *florid*.

The contractions of the whole heart at this time were powerful; and Mr. Hunter's thermometer being raised to 98° was introduced through an opening in the pericardium, and placed on the right side; the mercury rose to 99° and then became stationary; it was removed to the left, and the

temperature was the same; but on making an aperture into the left auricle, and thrusting the bulb down to the ventricle, the mercury fell to 97° ; and on placing it in the same manner within the right ventricle, it rose above 98° .

From frequent repetitions of this experiment it uniformly resulted that, although the temperature of both sides of the heart externally was equal, yet the heat of the blood in the right side exceeded that of the left, from one to two degrees.

This observation may appear rather strange, and at first seems to contradict the opinion that respiration is the source of animal heat; but the fact can be readily explained; for the blood, in its passage through the lungs, being contained in vessels that are in contact with air so much below its own temperature

temperature, the colder body must rob the warmer of so much sensible heat as is necessary to make them nearly equal ; and the temperature of the substance of the left auricle and ventricle is kept up above that of its contents, and equal to that of the right side from the heat evolved by the blood in the coronary vessels ; but as the sensible heat of the blood in its passage through the lungs is only slightly diminished, its latent heat must be considerably increased. Indeed when it is considered that the blood vessels in their passage through the lungs are always exposed to the air inspired, and that the heat of this air is often increased or diminished 40° of Fahrenheit, without altering the warmth of the blood even 3° , can there be a doubt but that the blood which warms the air must in the lungs *receive a fresh supply* of heat ? If the pulmonary vessels were distended

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with

with water (instead of blood) at 98° of heat, and the air inspired was only 32° , the contents of the pulmonary veins and left auricle would be much below 98° , whereas the temperature of this blood, whether the air be warm or cold, is generally uniform. The atmosphere at 72° , or at 32° , would make a most material difference on water at 98° , or any other fluid but living blood. Hence it follows, that while the blood in the lungs is parting with its sensible heat to the air, it is absorbing, in a concealed form, latent fire.

It has moreover been found that when the change has taken place, the blood in the left side of the heart retains its heat longer than that in the right, though at first its temperature be somewhat inferior.

To establish the fact the following experiment was made.

EXPERIMENT:

A cat was strangled, the chest immediately opened, and the lungs inflated, when the blood in the left side of the heart became florid; an aperture was then made in the pericardium, and the mercury of a thermometer being raised to 99° , the temperature both of the right and left sides of the heart was exactly 98° : on opening the left and introducing the thermometer, as in the last experiment, it fell below 97° ; but on examining the right internally, it rose to near 99° .

So far does this experiment agree with our last; but the temperature of the blood was re-examined fifteen minutes after, and

D 2

instead

instead of the right possessing two degrees of heat more than the left, it was found, on the contrary, that the right had four degrees less than the left.

This experiment has been repeated by Mr. Astley Cooper, and in different ways, but the result has been invariably the same; that although the venous blood was superior in temperature at first, yet before coagulation was complete, the arterial became from three to six degrees warmer; this, or nothing, affords a proof, that heat is received by the blood from breathing; for if that blood which has passed through the lungs, is at first inferior in temperature, and soon after becomes superior; from what can this variation arise but the heat received from the air in a latent form, and evolved in a sensible one?

We scarcely know of any animal, on whose blood the air does not, either directly or indirectly, induce some change ; and the great object of this change appears to be the support of animal heat ; and from the heat evolved the *irritability** of the animal is supported.

There are animals whose atmosphere is equal to their own heat ; and it has been the opinion of some physiologists that in these instances their animal warmth is supported by the surrounding medium. If this be ever the case, it probably is in ascarides, and other animals of the same species, where the temperature of their medium scarcely ever varies ; but I should much doubt if this be the œconomy of any animal which is placed in an element subject to alterations of

* The term irritability is here employed to express nothing more than a *susceptibility of action*.

temperature. Nature has very wisely ordained that animals should possess a power of retaining nearly an equal temperature for a time, whether they be exposed to excess of heat or cold; which seems to shew that their heat cannot be communicated by external temperature; indeed, if animals had not a source of heat within themselves, and yet placed in an element liable to variation, life could not be sustained.

It requires no great strength of argument to prove that animal warmth is not produced by the stomach. The simple observations that, in fevers, when the sensible heat is greatest, less food is taken into the stomach than in health, and that the infant, as soon as respiration commences, and before the stomach receives any nourishment, is not less warm than the adult, are sufficiently convincing that the stomach is not
to

to be regarded as the source of animal heat.

That mere distention is the ordinary stimulus that excites the action of the heart, is the opinion embraced by some physiologists. Nor is it indeed improbable that a certain degree of distention produced by blood of a due temperature, constitutes the principal power which stimulates the heart to contract; for this power of reaction, when stretched beyond a certain tone, seems a property inherent in all muscular fibres.

Nor do we deny that the heart, when void of blood, and separated from the body, retains this action; but this is not peculiar to the heart alone; muscles, whose natural actions depend on the stimulus of the will,

D 4 possess

possess it likewise, though in an inferior degree.

That the different sides of the heart require different stimuli, and that there is something peculiar in florid blood, which alone is capable of exciting the left side to action, we cannot with Dr. Goodwyn admit.

There are several objections that militate against this opinion. Why should the same fibres, nourished by the same vessels, supplied with nerves from the same source, and *performing the same functions*, be excited to action by different causes? Some of these objections the Doctor is aware of, and attempts to remove them by observing that the animal machine offers instances where muscles of similar structure are put into action by different stimuli; but this is not
 saying

saying that muscles *performing the same functions*, act from dissimilar causes, which it is necessary to prove before any analogy can be established to favour this hypothesis.

It is far therefore from being certain that the different sides of the heart derive their action from different stimuli : and let us but examine the foetal circulation, and it will appear that both sides of the heart contract from the stimulus of blood nearly of the same quality ; that this blood is not florid in either ; for even in the umbilical vein it has undergone but a very imperfect change *, if compared with that induced on the blood which passes through the lungs of the adult ; moreover, that the greater

* We take it for granted that the old opinion, of there existing an actual circulation between the blood vessels of the mother and child, is now exploded, as numerous experiments have been made to prove the contrary.

part of the fœtal blood arrives at the heart without passing through the placenta at each circulation: that is, the blood in the heart of the *adult* will receive a complete change in the lungs, before it again returns to the same place; whereas, the whole of the blood in the fœtal heart will not go to the placenta, to receive the alteration at each revolution; but by far the major part will be sent to the trunk, the head, and extremities, and be returned to the two cavæ, without having entered the umbilical arteries.

The blood in the umbilical arteries is similar to that in the trunk of the pulmonary artery of the adult circulation; that is, possesses but a small proportion of latent heat; whereas that of the mother in the cells of the placenta is pure arterial blood. In the minute branches of the umbilical arteries a change is performed; but *only* so much
latent

heat is imparted to the foetal, by the maternal blood, as is necessary to restore the equilibrium of absolute* heat. The heat therefore which is received by the foetal blood will be small, in comparison with that imbibed by the blood of the adult in the act of respiration; as *only* that quantity of heat can be imparted from the maternal to the foetal blood, as can make both their qualities with respect to heat *equal*.

When the foetal blood has undergone this change, it is returned by the umbilical vein; and part of it will pass through the ductus venosus † into the inferior cavæ, and mix with the blood brought from the

* By absolute heat, we mean the latent and sensible heat combined.

† The horse has no ductus venosus; the blood therefore in the umbilical vein of this animal must all pass through the liver.

lower extremities ; but a greater part will pass through the vena portarum to go to the liver, where by passing through capillaries, it must assume the venous quality before it arrives at the right auricle ; it then unites with the blood sent from the lower extremities and trunk of the body in the inferior cavæ, and on entering the right auricle it mixes with the stream of blood coming from the head and superior extremities, none of which has been to the placenta to receive the change.

The right auricle propels part of this blood (which must be dark) into the left, and all the blood that passes through the capillaries in the lungs also enters the left, so that the blood which produces the contraction of the left side of the foetal heart must be more completely venous than that of the right, as part of the blood in the left
auricle,

auricle, without receiving any supply of heat, has passed through, and imparted heat to the lungs.

If the quantity of blood conveyed to the placenta by the umbilical arteries, be compared with that sent to the head, superior and inferior extremities, and trunk, it will be found that not one fifth part of the blood goes to the placenta at each revolution, nor can this blood receive but *half the heat* the maternal blood contains; moreover, as all the blood of the foetal horse must first pass through the capillaries of the liver before it arrives at the heart; and as that of other animals which does not all pass through capillaries mixes with venous blood, it is obvious that both sides of the foetal heart contract from the stimulus of black blood, and that the blood of the left side must be blacker than that of the right.

From

From the blood in the foetus receiving a degree of change so inconsiderable, when compared to that produced in the adult by the same process, a doubt might at first arise whether in both it was destined to accomplish the same end, the support of animal heat, and from thence that of *animal irritability*. But the foetal circulation, far from invalidating, countenances the opinion which derives animal warmth from the act of respiration.

The experiments of Dr. Crawford have already enabled us to observe that the quantity of heat absorbed in breathing is proportional to the temperature of the surrounding medium. The observation holds equally good in the foetal circulation; for as the foetus is surrounded by the liquor amnii and uterus of the mother, the quantity of heat consumed must be extremely small; and
the

the temperature being uniform, there is no occasion for more being absorbed than is necessary to supply the consumption of foetal heat. If the whole of the foetal blood went to the placenta at each revolution, the heat absorbed would exceed the demand, and produce mischief; for the power of *resisting* heat must then be called forth to action; and this in the foetus is very inconsiderable.

On the adult, nature has wisely bestowed two powers for generating cold; that of evaporation from the surface of the body, and a power independent of this; but the foetus can only possess the latter, as no evaporation can take place from the surface of the body; and as the foetus is deprived of this power, and as the temperature of its surrounding medium, the liquor amnii, is so much above that of our atmosphere, if an
equal

equal degree of heat were absorbed in the foetal, as in the adult circulation, the animal must perish ; since the act of resisting heat for a few minutes is very distressing, even where the additional power from perspiration is present, to counteract its destructive accumulation. Admirable therefore is the provision which nature has made, for maintaining a proper degree of heat, both in the foetus and adult ; the former is placed in a warm medium of uniform temperature, which permits but little heat to be consumed, and the circulation is so regulated as only to allow the absorption of a small and *limited* quantity of heat ; so that great powers for resisting heat are here unnecessary.

But in the adult, the varying and changeable temperature of the air makes it necessary that more or less heat be absorbed, to correspond with the variation to which it is
I
exposed.

exposed. We are therefore immersed in an atmosphere supplied with sufficient oxygene to answer our demand; and by evaporation, from perspiration, &c. we are enabled to resist heat, so as to prevent its undue and destructive accumulation. On the other hand, from the warmer medium which encompasses the foetus, we may gather the reason why a smaller portion of heat should be imbibed, and from this being *limited*, why it stands in no need of evaporation for the generation of cold.

Were the change induced on the blood during circulation intended *solely as a stimulus to support the action of the left side of the heart*, as maintained by Dr. Goodwyn, then should the alteration produced in the foetus be equal in degree to that produced in the adult; but that this is not the fact we have already, and we hope not unsuccessfully,

E endeavoured

endeavoured to prove; and indeed if this was the intention of nature, it is highly improbable that the connexion between the mother and child should take place at the umbilicus, where a great part of the blood which has been at the placenta of the human subject, and the whole of the foetal blood of the horse must first pass through capillaries before it enters the left auricle, and where its purity in the right side of the heart must be superior to that in the left. We might sooner suppose that the umbilical vein would have terminated in or near the left auricle, to supply it with blood thus duly altered, than that the blood contained in the *left side of the heart* should be *similar in quality* to that in the umbilical arteries which goes to *receive* the alteration; for, in the foetal circulation, the vein contains blood that has absorbed oxygene, but the arteries carry blood that is going to receive it.

If

If therefore the left side of the foetal heart and the whole of the arterial system possess no stimulus but that of black blood; if the pulmonary artery in the adult be excited only by this blood; if, in a word, the heart of fishes act on no other blood; is it not obvious (at least as far as induction and analogies can prove) that in the adult also venous blood can excite the action of the *left side of the heart*, and consequently that the two sides of the heart do not require to be stimulated by dissimilar causes?

From considering that one side of the heart in the adult circulation contains black blood, and the other florid; and that in suspended respiration the left side first ceases to act, when both contain black blood; Dr. Goodwyn, we presume, was induced to conclude that venous blood, which supports the action of the right side,

was an unfit stimulus to keep up the action of the left.

The observations, however, we have ventured in support of the idea, that the whole of the heart owes its action to one and the same cause, oblige us to withhold our assent from that of Dr. Goodwyn.

We have already observed that when the blood arrives at the right side of the heart, it has lost the greater part of its latent fire : in health it is to receive a fresh supply, and is then propelled into the left side of the heart, and through the whole of the circulating system, to evolve and distribute heat.

In consequence of this process, the left side of the heart and coronary vessels are supplied with blood, which distribute heat
and

and nourishment to the whole of the heart ; and in ordinary circulation it is probable that the heart derives its heat principally from the blood in the coronary vessels ; but if the motion of the circulating fluid be checked, or totally suspended, then would the blood in the cavities of the heart continue to undergo the same process ; at least so long as it possessed any heat in a latent form : for it has already been proved, that if blood be delayed in the larger arteries, it is known to assume the same change and appearances as when it has passed through capillaries. The blood within the coronary vessels not only supplies the left side of the heart with heat, but also the right ; and although the blood in the left side of the heart may contain 60 degrees of latent fire, when the right possesses but six ; yet if the *sensible heat evolved* be only

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equal

equal to two, their temperatures will be the same.

The result of multiplied experiments authorizes the assertion, that immediately after the action of the left side of the heart is increased by florid blood, the right also becomes equally affected; nor is this effect an unnatural or unexpected consequence; for as the coronary vessels soon receive this blood, and as these vessels are going to both sides of the heart, the heat and irritability of both must be equally increased.

One of the stimulating powers that keeps up the *action* of the heart, we have already supposed to be distention; but this must cease to act as a stimulus whenever the quality of the blood becomes incapable of supporting the irritability of the heart, by imparting to it a certain proportion of heat.

Dr.

Dr. Cullen imagined that the heart's continuing to act after breathing had ceased arose from habit ; but were that the case, why should the action of the right side of the heart outlive that of the left ; and why should not this influence of habit extend equally to arteries ?

Inflating the lungs soon after respiration has ceased, generally increases the action of the heart. This in the first instance depends on the process of circulation being forcibly carried on and assisted by the necessary stimulus imparted from the air to the blood of the coronary arteries, which increases the living powers of the heart and renders it more susceptible of action.

To this opinion, of the action of the heart proceeding from mechanical stimuli, Dr. Goodwyn opposes this inference : If it were

so, says the Doctor, any aerial fluid would be then equally effectual. But this is not conclusive ; for it is agreed on all sides, that a change in the blood is necessary to the life and uninterrupted action of the heart : and although the introduction of noxious air into the cavities of the heart may prove a stimulus to the fibres of the heart, yet if the blood ceases to receive the change, the irritability of the heart must necessarily diminish. That it is not to be ascribed to any change immediately induced on the blood *already in the left auricle* is evident ; for the right side of the heart must be excited to action before the left can receive blood that has undergone the change ; as no alteration can be given to the blood contained in the auricle,

Dr. Goodwyn is of a contrary opinion ; for he observes, “ that the contractions of

“ the left auricle and ventricle are immediately effected by the quality of the blood passing into them.”

We shall endeavour in the next section to demonstrate, by experiment, that no alteration can be produced on the blood in the trunks of the pulmonary veins and left auricle, if the communication be cut off from the right side of the heart: and it must be manifest, that if the blood *already* in the left auricle could receive an immediate change from the air in the lungs, the right, which is equally in contact with them, should also receive it.

That the right side of the heart continues to act after the left has ceased, is a phænomenon that has been noticed by many physiologists; but few, if any, have attempted to unfold its cause. Indeed

Dr.

Dr. Goodwyn appears to be the only one who has seriously endeavoured to explain its rationale, and attempt its illustration; and though there is no authority to which we would more gladly refer, yet we cannot here adopt his opinion, *that the left auricle and ventricle first cease to act, from the ineptitude of venous blood to excite their contraction; and that this is the immediate cause that suspends circulation in drowning, &c.*

But in order to explore the true cause of this phænomenon, let us once more recollect that the blood, when it arrives at the right side of the heart, has lost the greater part of its latent heat; that in health it receives this supply in the lungs; but that, *in suspended respiration*, the blood passes through the minute ramifications of the pulmonary artery into the pulmonary veins, without receiving this necessary quality,
and

and instead of *absorbing*, must *evolve its heat*.

An essential difference thus takes place between the blood of the two sides of the heart ; the right is distended with blood that still possesses latent fire to evolve ; but the left has little blood in quantity, and that little has not received but given out heat, to the whole substance of the lungs ; and as the blood in the one is furnished with more heat to evolve than the other, and as the stimulus of distention is greatest at the right side, the action of the one is continued when no effect is produced on the other.

That, in ordinary circulation, both sides of the heart might derive their heat principally from the blood in the coronary vessels, has already been remarked ; but as this blood in suspended breathing contains little

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or no latent heat, from having evolved it in the lungs, the heart must in that case imbibe its heat from the blood contained within the cavities; and that this process can be carried on in them we have already shewn, so long at least as their blood possesses latent heat to give out, and while the circulation is retarded or totally stopt. From which we conclude, that *if the right side of the heart in this disease possessed the blood of the left, and the left the blood of the right, the difference of irritability would be reversed.*

If, however, we have succeeded in establishing as facts, that when the blood arrives at the right side of the heart it still contains a portion of heat in a latent state; that this blood in suspended breathing continues to evolve heat in a sensible form; that the inferior degree of irritability in the left side depends on the essential difference in the
quality

quality of its blood from that of the right ; that moreover this difference in quality proceeds from that of the left having been robbed of a quantity of its heat in its passage through the capillaries of the lungs ; if, I say, these facts can be established, then the temperature both of the right side of the heart, and its contents, should be greater than that of the left in this disease.

The result of the two last experiments we have mentioned, allowed us to conclude, that both sides of the heart externally are of the same temperature when the blood has received its due change from the air, though the temperature of this blood thus altered is inferior to that of venous ; and though the warmth of the blood of the left side be at first lower in degree, yet its heat soon after becomes predominant.

The

The next experiment was made, to ascertain the temperature of the two sides of the heart, and their contents ; where no change had been given to the blood.

EXPERIMENT.

A Rabbit was strangled, and the chest being opened, a small aperture was made in the pericardium, and a thermometer of Fahrenheit's scale was applied to the right side of the heart. The mercury rose to 96° , where it remained stationary ; it was then removed to the left, where it fell to 94° . On placing it within the cavity of the right auricle, the mercury again rose to 96° , and when applied in the same manner within the left, it fell somewhat below 94° .

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This experiment was repeatedly made on animals that had been drowned and hanged, both without and within the heart, and there occurred a few instances where there was scarcely any difference in the temperature of the two sides at *first* ; but in all the temperature, both of the heart and its contents, was predominant in the right, before the left side had entirely ceased to act. It therefore appears, that the blood which passes through the lungs into the left side of the heart, without receiving from the air the necessary change, instead of being more tenacious of its heat than the right, on the contrary loses it sooner.

Thus we see the result of experiment sanctions and justifies the predictions of theory, that when blood passes from the right side of the heart to the left, without having been exposed to oxygene to absorb its heat,
it

it must evolve in passing through the capillaries of the lungs what little heat the blood contained in a latent state: and the left side being no longer supplied with its due nourishment and warmth, either from the blood in the coronary vessels, or from that contained in its own cavities, must have its temperature reduced, its irritability decreased, and its action gradually suspended, by the diminution of its stimulus of distention.

But far different is the condition of the right side; for although the blood in the coronary vessels is incapable of supplying it with heat, yet the blood within its own cavities contains a quantity in a latent form, which it continues to evolve; thus is its irritability supported, and thus, by continued distention, is its action kept alive.

Dr.

Dr. Goodwyn having observed that in this disease all the cavities of the heart contain black blood, was induced to conclude that its other qualities were exactly similar; but had it been considered that in these circumstances the blood, in its passage through the lungs, suffers a deprivation of its remaining heat, without the accession of a new supply, the cause whence originates the difference of irritability in the two sides of the heart would have no longer remained obscure, nor would the Doctor, to explain this phænomenon, have been reduced to the supposition that the same muscular fibres were excited to action by different causes, and that the blood of the same quality that stimulated the right side to contract, was incapable of producing the same effect on the left; but this difference would have been discovered to arise from the left having lost

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a greater

a greater portion of its heat, and the stimulus of distention being diminished beyond that of the right.

The advantages derived from this property of the right side of the heart, which supports its action after that of the left is suspended, seem to have escaped the notice and eluded the research of physiologists, yet no provision of nature more deservedly claims our admiration and inquiry; for in no department of the animal œconomy has she adopted a wiser precaution for the preservation of life, than, after the last expiration of the animal, prolonging to the right side of the heart a stimulus and power of action superior to that of the left.

Let us but suppose the reverse, that the left had the irritability of the right, and the
right

right the irritability of the left; as it is found necessary to the effecting a recovery, that the right should first contract, and supply the lungs with blood to receive a change from the air in order to excite the left side of the heart to action; the right, in this supposition, would soon be incapable of performing this function; whereas, from the right continuing to contract after the left is motionless, it is thus capable of propelling blood through the lungs into the left auricle, which being once restored by the arrival of duly prepared blood (even though it should have ceased to act from the stimulus of its own) is enabled, by the fresh supply of this stimulating quality, to revive, and the action of the whole heart is increased; but if the irritability of the left side were at first predominant, it would get rid of its own blood, and the feeble action of the *right side* be incapable of supplying it with more.

Thus at the very origin of the circulation, where the fresh stimulus is last applied, Nature, ever wise in her operations, has prudently placed a superior degree of irritability; while in the left, where the irritability is inferior, the increase of stimulus is first received: nor will this be deemed the result of chance, if we but recal an observation we have already mentioned, that in the foetal circulation, the stimulating quality of the blood is greater in the right side of the heart than that in the left, and that in the adult it is reversed.

But although the blood in these two states of the animal possesses this difference of stimulus in the different sides of the heart, yet, if an injury threaten the life either of the foetus or of the adult, the right side of the heart will be found to contain blood of a stimulating quality superior to that of the
left,

left, and consequently greater irritability ; for let us suppose that, at the time of birth, the umbilical chord is prevented from carrying on the circulation to and from the placenta, the blood that runs to the left heart, from its being obliged previously to pass through the capillaries of the lungs, is deprived of a portion of its stimulus : and thus, in the morbid state, is the same provision made for the foetus as for the adult, though their natural circulation be widely different.

There is reason to suspect that in man there does not exist so much irritability as in animals of more simple construction ; for it seems that in the more perfect or complicated, as man, whose sentient powers are greatest, the vital are least ; and we believe this will hold good in gradation with all the

inferior animals, that, in proportion as the *sentient powers abound*, the *vital diminish*, and *vice versa*.

This is strikingly exemplified in the polypus, which has been observed to regenerate into as many different polypi as divided into pieces; and these animals have neither brain or spinal marrow.

It appears therefore not improbable to be the intention of the great Creator, that those animals, whose powers for perceiving danger are less acute, should be capable of receiving greater injuries without the destruction of life, than those that are armed with this faculty in a superior degree.

All impressions made upon superior animals are immediately conveyed to the brain,
and

and this being the great sensorium, the whole animal receives the alarm, and an immediate effort is made to remove the cause of the injury. But inferior animals, that are unprovided with nerves and brain, that are consequently destitute of sensation, and whose powers of instinct are but feeble, Nature, we find, to compensate for this want of sensation, has enabled them to withstand injuries to a greater degree than those that are furnished both with brain and nerves. Animals also that are endowed with superior sagacity, possess but a small degree of irritability; and it seems to be justly remarked, that the irritability of animals decreases as they advance in age. This was certainly intended for the same excellent purpose, that of supplying the defect of sagacity while young; but when the sentient powers become adequate to the

necessity, this exquisite irritability, which was so wisely bestowed on them while young, is no longer required.

In different species of animals, we have sometimes observed that after respiration is suspended, from drowning, &c. &c. scarce any action remained in the right side of the heart; but in several experiments the cause of this phænomenon was found to arise from an over distention of the right auricle and ventricle; for when a small puncture was made in the anterior cava, and a portion of the blood contained in the right side of the heart expelled, its contraction became extremely powerful.

Here, then, was indirect debility brought on from over-distention; and there is reason to suspect that this morbid accumulation of blood may frequently happen
from

from the methods of recovery usually adopted, and in various other diseases.

There remains a susceptibility of action in almost every part of the body for some time after the suspension of the sentient powers; but as animals, whatever may be the cause of their destruction, begin to die first at the extreme and exterior parts; so, in suspended respiration, from drowning, &c. we find the irritability of the heart outlives that of any other part of the body. One exception, indeed, has occurred, where the heart and extremities ceased to act nearly at the same time.

From considering the length of time the heart may be made to contract after breathing has ceased, there can scarce be any doubt, if electricity be unable to excite it to action, but that life is irrecoverably lost;
for,

for, with Mr. Hunter, we imagine life and the power of action to be intimately connected. If, therefore, we are incapable of calling forth this power into action, by the stimulus of electricity applied to the heart, there does not remain the most distant probability that the effect can be produced by the application of any other stimulus.

In our attempts, however, to restore the life of the apparently dead, we are furnished with no criterion for determining when this power of action is thoroughly extinct; for the exterior parts may have lost this degree of irritability, and the heart still retain it. In some instances, the heart of young animals has been made to act by electricity from ten to fourteen hours; and a gentleman, on whose veracity I can rely, has informed me he has seen it contract even twenty hours after respiration was stopped,
and

and which is many hours longer than we have been able to excite action in any external part.

At first view it seemed probable that irritability and animal heat might be coequal ; that, from the latter being present or absent to a certain but unknown degree, we might be able to draw a prognostic of the presence or extinction of the other ; but subsequent observations discovered this to be erroneous ; for, as there are few whose solids are not very differently excited to action by the same cause, so the quantity of heat evolved from the blood, that would support irritability in the one, would produce no effect on the other.

This opinion is confirmed by the following experiments :

EXPERIMENT.

E X P E R I M E N T.

A small Puppy was drowned, and on examining the temperature of the two sides of the heart in the pericardium, the right was 98° , the left 96° . The right side of the heart continued to act for more than two hours; and during the last ten minutes its temperature was 60° , that of the left 57° ; the warmth of the air in the room 55° .

E X P E R I M E N T.

A full-grown Dog was hanged, the pericardium opened, and the temperature of the right side of the heart was 100° , the left 99° . The right continued to act not quite ten minutes, when its warmth was 90° , that of the left 87° and one-half: the temperature of the room was also 55° .

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Here, then, action continued in the one more than twelve times longer than in the other, though with a degree of heat much inferior. We have also had a farther opportunity of being convinced that heat and irritability do not always co-exist, from the bodies of two persons that had been executed. A powerful electrical shock was given, without producing the smallest external action, although three hours after execution the temperature of one was 80° externally, and the other 82° at the expiration of two hours and one-half.

This superior degree of heat, above that of the atmosphere, does not proceed from the presence of life; for the longer or shorter continuance of sensible heat of any animal must always be proportionate to the quantity of latent fire the blood contains, and the temperature of the surrounding medium;

medium; whereas the difference of irritability much more depends on the readiness with which the solids act when this stimulus is applied, than on the quantity of heat evolved.

Why the fibres of one animal of the same species should more readily act than those of another, from the same cause, and how we are to discover the different degrees of this susceptibility of action in each particular animal, is a question not less important than intricate to unravel. As we have endeavoured to prove that *heat and irritability* do not necessarily co-exist, this may at first seem to militate against the opinion of heat being essential to the support of irritability; but in reality it does not, for although the fibres of one animal shall act with its temperature at 60° , and the fibres of another shall cease with its temperature at 90° : yet this

only proves that the solids of the one act from a slighter cause than those of the other, and not that the stimulus of heat is wanting. A certain quantity of inebriating liquor shall produce violent effects on one person, when a much greater quantity shall have no effect upon another.

Diffimilar effects also take place from the same temperature ; for although the heat of one animal may exceed that of another, and where the inferior degree of heat is present, the greater effect be produced ; yet the *stimulus* in *quality* is the *same*, and the difference of action depends on the moving powers of the one being more readily excited to act than those of the other. Nevertheless, though no decisive prognostic can be drawn of the presence of *irritability*, from the presence of *any known degree of heat*, yet the nearer the degree of heat approaches

approaches to its standard the greater must be the irritability of that particular animal. But it will ever be better to fix no criterion of life, and make use of every possible means of recovery, in every instance, than to form a hazardous prognostic, that may prove fatal to hundreds.

Having now superficially examined the functions of the Heart and Lungs, we shall, in the next Section, endeavour to ascertain the common effects of suspended respiration from Drowning, Hanging, and Suffocation, and then proceed to ascertain the immediate cause of death.

SECTION

SECTION II.

On the common Effects of Drowning.

THE general effects of submerſion have been deſcribed by others; and the reſult of our obſervations will be found nearly ſimilar to that obtained by thoſe who have already written on this ſubject. But, as it was neceſſary firſt to examine the appearances of animals under that circumſtance, before any clear idea could be formed of the proximate cauſe of the diſeaſe, we ſhall begin with a deſcription of the viſible effects that uſually ariſe from drowning.

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As soon as an animal is immersed in water, air is expelled from its lungs, and immediate attempts are made, apparently with great difficulty, to inspire; in which a small quantity of water is taken into the nostrils and mouth. The animal betrays increasing uneasiness; again expels air, and takes in more water. The duration of these symptoms varies from one minute to four: when the muscles of respiration cease to act, and all struggling is at an end. Some involuntary motions, however, generally succeed. On opening the chest, we find the two *venæ cavæ*, right sinus venosus, auricle, ventricle, and pulmonary artery, loaded with blood; the left auricle and the left ventricle about half distended; the aorta and its branches containing a quantity of blood, which, in all its appearances, resembles venous. The lungs are discovered in a state of collapse, containing a very small
 quantity

quantity of water, in the form of froth. The stomach, on examination, presents also a little water, which probably passes into the œsophagus when the rima glottidis becomes closed by the epiglottis; for, as the water contained in the mouth is then refused admittance into the trachea, it should seem, that, at that moment, it makes its way into the stomach; so that, as soon as the animal attempts to inspire, water enters the orifice of the trachea; but this organ, as if conscious of not receiving its due element, rejects the water, which is then allowed to pass into the œsophagus. Air is again emitted, and new efforts made to inspire, when, upon the same sensation being produced, similar effects arise; and, after the last expiration, no more water enters the lungs, or stomach. If the rima glottidis as soon as irritated was not closed by the epiglottis, there would be found as

much water in the lungs as the animal had expelled air; and if the stomach or lungs continued to admit water after respiration had ceased, we should often find them fully distended: but, whether our examination be made immediately after the last expiration, or after the space of one hour, we find no variation in the quantity.

It has been supposed that no water enters the windpipe until the animal is dead: but the entire result of our experiments tends to prove that water does get into the lungs during the act of drowning; and that no animal, provided with lungs, can be drowned without this circumstance taking place. Indeed Dr. Goodwyn has proved this to be the fact, in a manner so convincing and satisfactory, that we need only mention, that the whole of our experiments

experiments to ascertain this point have uniformly agreed with his.

It has been mentioned by Dr. Goodwyn, and other Physiologists, that the right auricle and ventricle are found FULL; but there seems to be some degree of impropriety in the expression; for by the term FULL is generally understood, a *cavity replete without vacuity*; and if so, the left ventricle may be said to be *full* when distended only to half its natural size, as it adapts itself to the volume of blood it contains, and in proportion as the quantity increases, the cavity enlarges, until it attains a certain degree of distention, when it re-acts. If the heart, therefore, contain but a small quantity of blood, the sides of the auricle or ventricle will be in contact with it, and the cavity be thus obliterated. Hence we prefer the term *distention* to that of *fullness*.

The following experiments were made with a view to determine the exact proportion which the quantity of blood contained in the right side of the heart, bears to that in the left, after drowning.

EXPERIMENT I.

A Cat was drowned, and as soon as the usual struggles attending submerſion had ceaſed, the cheſt was opened, the two cavæ, pulmonary artery, and aorta were ſecured, and the blood contained in the heart carefully collected. The proportions of the right were to the left as 12 to 7.

The next experiment was made to aſcertain, whether, after the action of the heart had ceaſed, the proportions were altered.

EXPERIMENT

EXPERIMENT II.

A Cat was drowned, and when the heart had ceased to vibrate, the two cavæ, pulmonary artery, and aorta were secured as before. The proportions of the right were to the left as 2 to 1.

These experiments were repeated, and the quantities varied; sometimes being as 7 to 4, at other times as 5 to 2, or as 12 to 7. So that, at a medium, the proportions of the right are to the left as about $3\frac{1}{8}$ to $1\frac{6}{8}$. The lungs were uniformly in a state of collapse.

Dr. Goodwyn has made some experiments to ascertain the precise quantity of air contained in the lungs after death,

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and

and they were conducted in the following manner.

“ A dead body of ordinary stature was
 “ procured, and a close compress applied
 “ upon the superior part of the abdomen to
 “ fix the diaphragm in its situation ; a small
 “ opening was then made into the cavity
 “ of the thorax on each side, and upon the
 “ most elevated parts. The lungs imme-
 “ ately collapsed, and water was intro-
 “ duced at these openings, till the cavity
 “ was filled. The volume of the water
 “ contained was 272 cubic inches.

“ The person on whose body this ex-
 “ periment was made had been hanged.
 “ In four similar experiments, where death
 “ was natural, he found the medium was
 “ 109 cubic inches of air after complete
 “ expiration.”

These

These experiments, however, are by no means conclusive; for whatever may be the cause of death, the animal dies with an expiration, and the tendinous part of the diaphragm is thrust up as high as the fourth, and sometimes as high as the fifth inferior rib; and therefore the application of a compress round the abdomen does not seem adequate to prevent the diaphragm from descending. Could this event be effected, as the ribs cannot be kept at any fixed point, and as the air contained in the lungs was not collected, the experiment can by no means authorise any legitimate conclusion.

Dr. Goodwyn observes, that atmospheric air, by means of its gravity, will enter into the chest, and, by its pressure on the external surface of the lungs, oblige them to collapse. This observation, we presume,

fume, is inaccurate; for according to a well-known law in hydrostatics, air and all fluids press equally in every direction. However great, therefore, the quantity of air may be in the lungs after the last expiration, the pressure of the external air cannot be supposed to assist in expelling it. This appears obvious on a common bladder inflated, which the pressure of the external air by no means contributes to collapse, but in the same manner as the lungs, where the pressure is equal, its evacuation will depend on its own *elasticity* and *weight*.

Those who die a natural death must always have a portion of air remaining in the chest, since the lungs cannot be thoroughly evacuated by one expiration; but in drowning, &c. repeated expirations are made with ineffectual attempts to inspire. What, therefore, Dr. Goodwyn has advanced on

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this

this head, appears neither established by argument, nor countenanced by fact. But to determine the point, the following experiment was attempted.

EXPERIMENT.

A Cat was drowned, and after the usual struggles had ceased, the trachea was secured by a ligature, the chest opened, and the lungs taken out. A glass tube, divided into drachms and half drachms by measure, was filled with water, and inverted in a basin containing the same fluid. The trachea was then placed under the tube and divided, and the lungs being pressed, not half a drachm of air escaped. The same lungs when distended contained 16 drachms of air.

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This experiment was several times repeated on different animals, and sometimes scarce a bubble of air was collected; in no instance was the proportion of air in inspiration, to that remaining in the lungs after expiration, so small as 10 to 1. The Heart has frequently been observed to contract, or more properly to vibrate, for more than two hours after respiration was suspended, and that from no other stimulus but its own blood; while in other experiments the vibrations did not continue one tenth part of that time. The right side of the heart preserves its action much longer than the left, and the auricles longer than their corresponding ventricles.

The peristaltic motion of the intestines does not continue as long as the contractions of the heart; and on opening the head,
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the veins, as in ordinary death, are found rather distended, but without the least appearance of extravasation. Our next inquiries will be directed to the effects of hanging.

SECTION

SECTION III.

Common Effects of Hanging.

WHEREAS, in the lungs of animals that are suspended by the neck, there is always present a certain quantity of air; the idea has been suggested, that they possessed no power to expel it; and that, as the lungs would then be more or less distended, the disease arising from it must differ from that produced by drowning. To ascertain this point, the following experiment was made.

EXPERIMENT.

A dog was suspended by the neck. As soon as the struggles became violent, the
 fœces

fæces and urine were discharged. In less than four minutes he ceased to move. The air-tube was tied, the chest opened, and we discovered the same appearances after hanging as after drowning; the lungs collapsed; the right side of the heart overloaded with blood; the left auricle and ventricle about half-distended. The aorta and its branches contained blood, in quantity and colour similar to that from drowning.

Hence it appears, that, when an animal is suspended, the muscles of expiration are capable of performing their functions; nor are the muscles of inspiration deprived of their action: but, as the pressure of the cord overpowers that of the external air, and closes the opening of the trachea, the lungs are not found expanded, but collapsed.

Our

Our next object was, to attempt ascertaining the exact quantity of air that remained after hanging.

EXPERIMENT.

A dog was hanged; and, when all struggle and motion had ended, a ligature was made on the trachea, in the same manner as in those animals that had been drowned; the lungs were then removed; and the orifice of the trachea being placed under the glass tube filled with water, the ligature was taken off. On pressing the lungs somewhat more than a drachm of air escaped. These lungs, when inflated, contained forty-three drachms and one half of air. This experiment was often repeated; and sometimes scarcely any air could be expressed from the lungs. At
other

other times, the proportions in inspiration were, to those in expiration, as 11 and 12 to 1: but, in all instances, the quantity of air that remained was very inconsiderable.

In the next experiment, we endeavoured to ascertain the exact proportion of the blood in the right side of the heart to that in the left, after hanging.

EXPERIMENT.

A dog was suspended by the neck till he ceased to move. The two cavæ, pulmonary artery, and aorta, were secured by ligatures; and, after a careful inspection of the heart, it was found, that the proportion of blood in the right, was, to that in the left, as 2 to 1.

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The same experiment was repeated on a cat, and the proportions were as 5 to 3. On a repetition of these experiments, it appeared that in some the proportions were as 9 to 4; in others as 5 to 3, and as 7 to 4. So that the medium stands as 28 to 15.

The contractions of the heart and the peristaltic motion of the intestines continue nearly as long after hanging as after drowning, the veins of the pia mater seem more distended, but without any extravasation.

SECTION IV.

Common Effects of Noxious Airs.

IT has been generally supposed, that when animals were immersed in any air unfit for respiration, it was both taken into their lungs, and again expelled. During which process a deleterious effect was produced on the system that terminated in death.

This supposition is, however, supported neither by argument, experiment, nor analogy; for we find the lungs equally *collapsed* in those animals destroyed by noxious air, as in those which have been drowned. In both cases, the first expiration is by no means sufficient to exhaust the lungs.

The animals attempt to inspire; when they become conscious of receiving an improper element, and the epiglottis closes. Air continues to be expelled, and new attempts are made to inspire, when the trachea being again irritated by the noxious air, little or none enters the lungs, and after the last expiration they admit no more.

In order to discover the precise quantity of air now retained, we made the following experiment.

EXPERIMENT.

A kitten was immersed in nitrous gas, and when it had ceased to breathe, the trachea was secured, and the lungs removed. The air was then collected as before, in the glass tube; and it amounted

only to $\frac{1}{2}$ of a drachm*; whereas, in the distended state, these lungs contained 14 drachms and $\frac{1}{4}$.

In the repetition of this experiment, different kinds of impure air were employed; and the proportion of it in the distended to that of the collapsed state was frequently as 40 and sometimes even 50 to 1; and in every instance the quantity of remaining air was very inconsiderable.

The next object was to determine the exact quantity of blood in the right and left sides of the heart.

To ascertain this, the following experiment was repeated.

* We here mean the same bulk occupied by half a drachm of water.

EXPERIMENT.

A rabbit was destroyed by nitrous gas; after which, the two cavæ, pulmonary artery, and aorta, were secured. The blood, in the right and left heart, was then collected. The proportion of the former was to that of the latter not quite as 3 to 2.

From a repetition of this experiment we learned, however, that, although the proportion was sometimes not so much as 3 to 2, yet, in one instance, it was more than 2 to 1.

As a medium, therefore, the quantity of blood contained in the right, may be to that in the left as 5 to 3.

We

We here also remarked, that the irritability of the heart continues but little longer than the peristaltic motion of the intestines; and that, in these experiments, they both ceased sooner than in animals destroyed by drowning or hanging. Nor was this irritability in any one instance manifest from artificial stimuli after respiration had been suspended one hour and five minutes. In some rabbits, destroyed by nitrous gas, the heart ceased to contract, from its own stimulus, in less than four minutes.

From the uniformity of these effects from various airs, we are authorized to conclude, that the airs in which the animals were immersed contributed by their specific quality to destroy their irritability.

I shall not deny that this effect is to be

H 4 attributed

attributed to the noxious quality of the air entering the lungs; but should rather suspect the bulk of this air, taken into the chest of suffocated, does not more than equal that of the water admitted by drowned animals: for as the latter at each inspiration receive only a small quantity of water, it is probable the former admit only the same quantity of noxious air, which, mixing with what remains in the lungs, is at length nearly all expelled by repeated expirations; and a similar collapse takes place to that which we have already observed accompanies hanging and drowning.

It has been remarked, that animals destroyed by impure air do not grow rigid, but remain pliant and flexible. We have, however, in the course of our experiments, met with striking examples of the contrary.

Animals

Animals killed by nitrous gas become sooner rigid than those destroyed by drowning; and in two instances, the rigidity of the extremities was remarkable, even before the heart had ceased to vibrate.

On examining the head, the veins were found in a small degree distended.

From this brief inquiry into the visible effects arising from hanging, drowning, and suffocation, these trifling variations were observed:—that in one instance water enters the lungs; in the other noxious air: that this air possesses a greater tendency to destroy the action of the heart than either hanging or drowning, and that, after the former, more blood is found in the head, though its proportions in the different sides of the heart are nearly equal.

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The lungs in all these are in a state of *collapse*. These considerations, especially the *last*, incline me to believe, that the cause which produces death in one instance, operates also in the others.

SECTION

SECTION V.

An attempt to ascertain the proximate cause
of the disease produced by Submerſion,
Strangulation, and Suffocation.*

TO inveſtigate and eſtabliſh the proximate cauſe of the diſeaſe in ſuſpended reſpiration from drowning, hanging, &c. is a taſk that has engroſſed the attention, and exerciſed the pens, of ſeveral eminent phyſiologiſts; but there has been little coincidence of opinion; each ſeeming to have ſtarted, and embraced an hypotheſis of his own.

* By proximate cauſe I mean, the condition of the parts diſeaſed, and, which being removed, the diſeaſe ceases.

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It has been the idea of some, that the air contained in the lungs becomes highly phlogisticated, and that, from its deleterious influence originates the disease. Others attribute it to a congestion of blood formed in the heart and lungs ; while another class suppose death to be produced by apoplexy.

To none of these opinions does Dr. Goodwyn incline ; to him it appears that, from the privation of the usual stimulus supplied by the air, the blood *contained in the left auricle and ventricle* is rendered incapable of exciting their contraction ; and hence he derives the *immediate cause of the suspended circulation*.

From an authority we so highly respect, it is with diffidence I dissent ; but the result of experiment tends to prove this opinion to be erroneous.

If

If the presence of black blood in the left heart was the *proximate cause* of circulation ceasing, then we should certainly find it *fully distended* from the action of the right; but Dr. Goodwyn himself admits that this is by no means the fact: and, indeed, if the left auricle and ventricle were *fully distended*, and it were necessary for the restoration of life that the blood *already contained* in the left auricle should undergo a change before it was enabled to empty itself, then every animal would be irrecoverable as soon as this black blood had once distended the auricle; for we can appeal to the test of experiment to prove, that no alteration can be produced on the quality of the blood contained in the trunks of the pulmonary veins and left auricle.

To ascertain if any such change could be effected, the following experiment was made.

EXPERIMENT.

EXPERIMENT.

A Dog was suspended by the neck until he ceased to move; on opening the chest, both sides of the heart were observed to contract; but the left ceased in eight minutes, while the right continued to act strongly. The pulmonary artery being carefully separated from the aorta, and secured by ligature, we proceeded to inflation, which was continued fifteen minutes, without being able to empty the trunks of the pulmonary veins and left auricle, or produce any apparent alteration on the quality of the blood.

This experiment was repeated on a cat, during the action of the left side of the heart, which became less distended, but no
alteration

(III)

alteration in the colour of its blood could be produced. The change therefore which the blood undergoes in its passage through the lungs, is effected before it enters the *trunks of the pulmonary veins and left auricle*, and as the air cannot come in contact with *this blood* to produce any chemical alteration, it must be propelled through the system unaltered, whenever an animal recovers; for supposing the blood within the lungs to have undergone its usual change from inflation, as the trunks of the pulmonary veins and left auricle are here understood to be *full*, and as *this blood* can receive no chemical change, the left auricle must act on its *black blood*, and receive the contents from the trunks of the pulmonary veins (which we have said has not undergone the change) before the left heart can contain blood duly prepared by the air. We were, at first induced to believe

lieve that the collapse of the lungs after inflation might have the power to empty the left auricle mechanically, by propelling the contents of the pulmonary veins onward, and by the pressure thus applied from without, to the blood within the auricle, to stimulate its muscular fibres to react, and so expel a portion of its contents. But there seems an objection to this supposition; for if the lungs by their collapse had any such power, they must have exerted it at the last expiration, and then those vessels which are affected by this action would be so far emptied as to require a fresh supply of blood from the right side of the heart before the lungs could, by their collapse, have any mechanical effect on their contents; and the next experiment proves, that, after respiration is suspended, very little blood is left within the lungs.

EXPERIMENT.

EXPERIMENT.

A Cat was drowned, and, when all motion had ceased, we opened the chest and secured the pulmonary artery. A small ligature was then passed round the trunks of the pulmonary veins, as they enter the left auricle, and both auricle and ventricle were then opened; the blood being all taken up by a sponge, the trunks of the pulmonary veins were divided, and on pressing the lungs very little blood escaped, except that contained in the trunks. The repetition of this experiment afforded the same result. We must therefore look elsewhere for reasons to account for the action of the left auricle in recovery, as experiment proves, that by inflation no chemical

I change

change within the trunks and auricle can be produced, nor by the mechanical action of the lungs, if the communication be cut off from the right side of the heart, empty the trunk; as this, I say, cannot be effected, it would seem that when the right side of the heart acts during inflation, there is a quantity of blood sent within the lungs; and this contraction, assisted by a collapse of the lungs, propels a portion of the contents of the pulmonary veins onward, and thus produces such a vis-a-tergo on the blood within the auricle, as to excite it to contract. It has been before observed that the right side of the heart *in health* performs this function independent of any mechanical action of the lungs, and it is likewise capable of the same action for some minutes after respiration is suspended; but where the contraction of this organ

organ is insufficient to propel blood through the lungs, producing an *artificial collapse* will have the same effect. This however can only happen where a fresh supply of blood has been sent to the lungs by the contractions of the right side of the heart; as experiment shews that the quantity of blood remaining in the lungs is too small to enable their mechanical action to have any effect on their contents.

It has been mentioned by Haller and other celebrated physiologists, that where the lungs are collapsed, an obstruction to the passage of the blood through them will be the consequence; but they have not proved *that the lungs are in such a state of collapse in Drowning, Hanging, and Suffocation.*

I have endeavoured to shew that Dr.

Goodwyn's experiments to determine this point were objectionable; and our inquiries presented results very opposite to his, that instead of the lungs being distended that they were collapsed, and contained but very little air. In order, however, to prove that *this degree of collapse* was sufficient to produce a mechanical obstruction in the lungs in Hanging, Drowning, &c. we compared the quantities of blood in the different sides of the heart, where the collapse was removed, to that where the collapse existed.

The experiments were conducted in the following manner.

EXPERIMENT.

A Dog was suspended by the neck, and in less than a minute the fæces and urine
were

were discharged; his struggles continued for little more than three minutes, when he ceased to move; the trachea was then laid bare, and divided, and the lungs fully distended with warm water (about blood heat) through the medium of a funnel; the trachea being secured so as to permit no water to escape, the chest was opened, and, contrary to all experiments made before, there was found a much less quantity of blood in the right sinus venosus, auricle, ventricle, and pulmonary artery, than in the left, which was loaded with blood, part coagulated, and the whole quite black. The experiment was repeated, and yielded nearly the same result, with this variation, however, that the right side of the heart had a little more blood than before, but the left was again fully distended.

It then appeared evident, that if by an

artificial distention of the lungs only, without the admission of air to produce any chemical change on the blood, the right side of the heart was capable of distending the left, and of expelling a part of its own contents; that in suspended respiration there exists such a *mechanical obstruction in the interior** *pulmonary vessels from collapse of the lungs*, as prevents the right side of the heart from getting rid of its contents.

The experiment was therefore repeated with some alteration.

EXPERIMENT.

A Cat was drowned, and after the cessation of all struggles, an aperture was

* By interior pulmonary vessels is meant those that ramify within the lungs, and are influenced by the air; and by the trunks we mean those vessels that arise from the auricle, and are attached to the surface of the lungs.

made

made in the trachea, and the lungs distended with air, which was retained. On opening the heart we found the contents of the left side were to that of the right as five to four.

EXPERIMENT.

A Dog was drowned; when he ceased to move, cold water was introduced into the lungs. On examining the heart we found the proportions of the blood in the left were to that in the right as six to five.

These experiments were repeated, and sometimes the proportions were as six to four; but in one, where the irritability was trifling, the blood was a little predominant in the right. On the contrary, in another, where great irritability was present, the proportions were as two to one.

It may be urged by some as an objection to the above experiments, that water may act as a stimulus to the pulmonary vessels, so as to excite them to act; but it has been observed, that there remains very little blood within the lungs after the last expiration; and if water acted on them as a stimulus, it could not produce the same effect on the trunk of the pulmonary artery, right auricle and ventricle, which we find in part emptied.

It has been observed that animals under the common method of suspension, retain the power of expelling air from the lungs; but it was found not impossible so completely to compress the trachea, as to prevent any air from escaping: with this view the following experiment was tried.

EXPERIMENT.

EXPERIMENT.

The trachea of a Kitten was laid bare, and a ligature passed round it, that the whole of the air might be confined within the lungs. The animal ceased to move in four minutes and a half; and on opening the heart we found the proportions of blood in the left side were to that of the right as nine to seven.

The same experiment was repeated on a Rabbit, and the proportions were as eight to seven.

In these experiments, therefore, where the muscles of expiration had not sufficient power to overcome the compressure of the cord, and expel air from the lungs, the blood accumulates to a greater quantity in
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the left side of the heart, because no collapse takes place, and consequently no obstruction to the passage of the blood through the lungs.

The next experiment was made on an animal that had been suffocated, by distending its lungs with nitrous air.

In order to perform this experiment a common bladder was produced, and a pipe affixed to its neck, small enough to be inserted into the trachea of a rabbit. This pipe was introduced through a cork adapted to the size of a wide mouthed bottle, which contained copper with diluted nitrous acid. The nitrous vapour arising from this solution was collected in the bladder, and when a sufficient quantity was obtained, we attempted the following experiment.

EXPERIMENT.

EXPERIMENT.

A small Rabbit was destroyed in nitrous gas, and as soon as it discontinued to expire air from its lungs, we removed it from the medium in which it was plunged. A small aperture was then made in the trachea, the bladder taken from the bottle containing the nitrous gas, and the pipe introduced into the trachea in order to distend the lungs; which being effected, the air was prevented from escaping, by tying the trachea. On examining the heart, the proportions of blood in the left were to those in the right as seven to six.

The experiment was again repeated by destroying an animal in hydrogen, and distending the lungs with nitrous air; and
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the proportions in the left were to those in the right as thirteen to twelve.

But these last experiments did not always produce the same result, a larger portion of blood being found in the right than in the left side of the heart, from the slight degree of irritability that remained after respiration had been stopt by noxious air.

Our next attempt was to ascertain if more blood were found in the lungs of an animal whose respiration was suspended, and then the collapse removed by a fluid, than where this suspension took place without the removal of the collapse.

We could devise no method to enable us to establish this point with accuracy, but ventured, however, on the following experiment.

EXPERIMENT.

E X P E R I M E N T.

A Rabbit was drowned, and the lungs immediately distended with air; after tying up the trachea the chest was opened, the pulmonary artery and aorta secured, as also the trunks of the pulmonary veins. The left side of the heart was then opened, the blood removed, and pulmonary veins divided, the ligature was taken from the trachea, and the air expressed from the lungs. A large quantity of blood flowed from the pulmonary veins, and in a few minutes, by alternate expansion and collapse, the lungs were emptied of their contents. No accurate comparison, however, could be drawn between the quantity of blood present in this experiment, and that which they contained in the collapsed
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state; but it was evidently less in the latter, which tends to confirm the opinion of the collapse of the lungs preventing a free circulation through them; for if more blood be found when they are distended than when collapsed, this it would seem must arise from the presence of an obstruction in the one instance, and its removal in the other.

These, together with the former experiments, conspire to prove that the collapse forms an impediment to the circulation; for if in an animal that is drowned, hanged, or suffocated, the blood be found to predominate in the right side of the heart, while in another destroyed by the same means, the contrary takes place merely from the introduction of a fluid into the lungs which can have no chemical effect on the blood; from what can this variation
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and difference of quantity originate, if not from the mechanical obstruction in the first case, and its removal in the second ?

It should however be observed, that, although repeated experiments prove mechanical obstruction to exist in suspended breathing ; yet it appears that the right side of the heart is capable of propelling a small quantity of blood through the lungs during the collapsed state of those organs for some little time after respiration has ceased, and the left of getting rid of *its black blood* ; an opinion that is strongly countenanced by the following experiments.

EXPERIMENT.

A Kitten was drowned, the chest immediately opened, and the aorta secured, without including the pulmonary artery ; when
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the heart had ceased to contract, the quantity of blood in both its sides was examined, and it was found that the left contained nearly as much as the right.

This experiment was frequently repeated, and sometimes the quantity of the blood was greater in the left side of the heart than in the right; but in all the experiments the quantity of blood in the left side of the heart was increased by tying up the aorta.

In the animals, therefore, subjected to these experiments, the blood must have passed through the lungs in the collapsed state; and if no ligature had been applied, this *black blood* would have been propelled into the aorta, since the period of examination of the heart after respiration has ceased,

makes

makes no alteration in the proportions of blood in their different cavities.

These experiments afford a result in direct contradiction to the opinion supported by Dr. Goodwyn, that the left side of the heart is incapable of acting from the stimulus of black blood: for they prove that as the right side of the heart is capable of sending blood through the lungs in the collapsed state, the left is also enabled to contract from the stimulus of *black blood*.

The same experiments may also at first seem to invalidate the opinion that supposes the presence of collapse. But whenever the right side of the heart has the power of propelling blood through the lungs in the collapsed state, the quantity is not sufficient to distend completely the left auricle and ventricle. And as the lungs in this

K disease

disease contain but very little air, and are nearly in the same state as the foetal lungs; and as only a small quantity of blood in the healthy state of the foetus can be propelled through that viscus; it appears that the blood passing through the lungs during the collapse in the adult, would not be sufficient for the demand, as very little more blood can be sent through the chest, after the last expiration, than in the foetal circulation; with this material difference however, that in the foetus a change has been given to the blood (in the placenta), while in the adult it can receive none.

Now as the left side of the heart soon ceases to possess a stimulus that can enable it to discharge its contents; so also the right cannot long continue to propel blood through the lungs in their *contracted state*: for if the right side of the heart continued
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to send blood through the lungs when the left was incapable of getting rid of its own, we should then find the blood predominate in quantity in the left.

Were Dr. Goodwyn's assertion true, that after the last expiration in drowning, &c. &c. the lungs contain a greater quantity of air than in *hydrops pectoris*, then an objection would arise to the supposition of their collapse forming an impediment to the free passage of the blood; but we have already attempted to detect the insufficiency of those experiments which he imagined authorized this conclusion.

It must however be confessed, that Dr. Goodwyn's experiments seem so ingeniously devised, and the conclusions drawn from them so specious, that at first they suspended inquiry; and it was only by

subsequent examination that we were able to detect the fallacy of those particular ones, which he adduces to ascertain the quantity of air remaining in the lungs after the last expiration. But, by pursuing a mode of inquiry different to his, we obtained a result extremely unfavourable, and indeed contradictory to his conclusion, viz. that instead of the lungs containing a large quantity of air after drowning, hanging, or suffocation, the residuum is very inconsiderable.

To this conclusion succeeded an obvious reflection, that if the circulation could be properly carried on during a *collapse* of the lungs, why should the foetal circulation differ from that of the adult? And indeed it appears evidently to be the intention of Nature, that only a small portion of blood should ever pass through the lungs
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in their state of *collapse*; for she, ever uniform as wise in her operations, would never have provided a different circulation for the foetus, if the vessels of its lungs could have admitted through them a free and uninterrupted passage to the blood; but as a collapse of the lungs was necessary to the foetal œconomy, it was indispensable that it should be furnished with a foramen ovale, ductus arteriosus, &c. to compensate for the small allowance of blood that is sent through them.

In drowning, &c. &c. as very little air remains in the lungs after the last expiration, the disease must exhibit nearly the same phænomena as the foetus, whose muscles of respiration have not been excited to act; for, in this case, it is nature that effects what we endeavour to attain by art; that is, to remove the collapse of the lungs,

and this by the introduction of a fluid that will give the necessary change to the blood.

Haller, Cullen, and others, were of opinion that the state of full inspiration was as unfavourable to the transmission of blood through the lungs, as that of expiration; but this supposition appears to be but ill-supported by fact; as experiment proves that, when the lungs were *completely distended by water*, the blood freely passed from the right side of the heart to the left; and the action of the heart, under this circumstance, must have been feeble, if compared to that which it exerts in a state of health.

It has also been the generally received opinion that where the *motion of the lungs* is by any cause impeded, the circulation,

from want of *their mechanical action*, is also suspended ; and that the accumulation of blood, which takes place in the right side of the heart, from drowning, hanging, and suffocation, originates from the same cause.

This opinion, however, has been contradicted by experiment, where, from the mere removal of the collapse, independent of any *mechanical action* of the lungs, the circulation through them was restored ; whence it is obvious that the accumulation of blood in the right side of the heart does not proceed from want of *motion*, but from the *collapse* of the lungs.

In drowning and in suffocation from foul air, it has been found that the veins of the head are not more distended than in natural death : and that apoplexy does

not take place, as has been supposed from hanging, is equally true; for if such were the case, a recovery could not be effected; since our endeavours to remove common apoplexy, even while the process of respiration and circulation proceed, frequently prove unsuccessful.

Were it really true that apoplexy took place either in drowning, hanging, or suffocation, we should conceive more sanguine hopes of recovery after breathing had ceased in ordinary apoplexy than when it arose from drowning, &c. for these latter causes produce their fatal effect in a few minutes; while common apoplexy, even where a predisposition existed, is generally many hours, and sometimes days, before death takes place. If, therefore, the two diseases be of the same species, that which arises from drowning, &c. must be much
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the more violent in degree. Were this indeed literally the fact, we should then, from drowning, &c. find great extravasation, and no recovery could be effected, and we should have reason to expect a recovery in those cases, where the cause was so slight as to require several hours to stop the natural actions: but as we are able to recover long after breathing has ceased in that disease, which, according to this theory, must be the most violent; and as we frequently fail of recovering from common apoplexy, even during respiration; it certainly proves that this disease, and that which takes place from drowning, are essentially different.

It has been advanced by some authors, that the mere distention of the vessels, without any extravasation either of blood
or

or serum, is sufficient to produce apoplexy; and this is the species of apoplexy which has been supposed to be produced in drowning, &c. as it is acknowledged that ^{the} ~~an~~ extravasation takes place in the head: but were congestion alone, in these cases, the cause of death, then must it be supposed that the distention alone of the vessels acts much more violently than when attended with actual extravasation; but this is an opinion not only discountenanced by probability, but also flatly contradicted by Valsalva and Morgagni on the stubborn faith of numerous facts. The latter observes
 “ that those cases are the most violent, and
 “ much the soonest mortal, which have
 “ their origin from *extravasation* within
 “ the cranium, we not only have daily
 “ proofs of ourselves, but it has also been
 “ frequently observed by others.”

It

It would therefore appear that though the vessels of the head were fully distended in drowning, hanging, and suffocation, this distention could not here be considered as the immediate cause of death, since at most it can produce but a very mild species of apoplexy ; for even when extravasation follows, the actions of life generally continue for hours ; while in drowning, &c. it is needless to repeat, the natural functions are in a few minutes abolished.

There still remains one observation, which proves the improbability of apoplexy happening from drowning, &c. and that is, that no accumulation of blood can be formed even at the right side of the heart, prior to the commencement of the collapse of the lungs ; but as soon as this obstructs the circulation, then the blood receives but an imperfect change ; and is therefore,
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in a great measure, deprived of its essential quality. From this circumstance it will no longer be capable of keeping up the full and natural action of the heart and arteries; and as the carotid and vertebral arteries will also have their action proportionably diminished, the impetus of the blood to the head must thereby be checked, and considerably enfeebled. These considerations induce me to believe that apoplexy can only happen where the blood receives its proper stimulus from the air to support the action of the heart and arterial system, and where an obstruction exists to its free return.

In apoplexy that proceeds from distention of the stomach, and other causes, the blood continues to receive its due stimulus from the air; while, for want of a sufficient expansion of the lungs, (the diaphragm
not

not being allowed a proper descent,) an obstruction arises to the free return of the blood, which occasions the disease. But, even in this supposition, death might not be the consequence, at least for many hours, if at all; although the vessels of the head might have been fully distended, and that by the natural action of the carotid and vertebral arteries; but as in drowning, &c. these vessels are soon deprived of their wonted stimulus, no injury whatever can happen to the brain.

From these observations, we trust it has been proved not unsatisfactorily, that apoplexy never happens in drowning, &c. But there is an experiment, which must always supersede argument, that seems to disprove the existence of apoplexy.

This experiment has been mentioned
before,

before, to prove a different fact; but as it is one that serves our present purpose, the repetition of it will therefore be excused.

EXPERIMENT.

The trachea of a dog was laid bare, and secured by a ligature, and this was endeavoured to be performed at the instant an inspiration was made; in less than four minutes he ceased to struggle. On examining the heart, we found the quantity of blood in the left, when compared to that of the right, as thirteen to twelve. A portion of the cranium was removed, and the veins of the head were evidently less distended than *natural*.

Here, then, there being no obstruction to the passage of the blood through the lungs,

lungs, it could not be collected in the right side of the heart, and consequently no accumulation was found in the head, and yet this animal died as soon as other animals from ordinary hanging; which carries conviction to my mind, that apoplexy forms no part of the disease,

As a further testimony, however, in favour of this opinion, the following experiment was made.

EXPERIMENT.

The two carotids of a Dog were secured *, and in half an hour after this

* This experiment of tying up the carotids in Dogs has been made both by Dr. Haighton, and Mr. Cooper, in order to ascertain the effects. I have also often taken up both carotids in horses, to remove staggers and other diseases of the head, without the smallest inconvenience to the natural functions of the animal.

operation

operation he was hanged. In less than four minutes he ceased to move; on removing a large portion of the cranium, the vessels were found much less distended than in *ordinary death*.

From this experiment, as the principal source of supply was cut off, instead of the vessels of the brain being in a state of congestion, the quantity of blood they contained must have been less than natural, and consequently no species of apoplexy could follow. Yet this animal died as soon as other animals which had undergone no such operation.

Dr. Crawford's experiments evince, that when an animal is placed in a warm medium, the venous blood becomes nearly florid.

With a view to ascertain if an animal could be drowned, and the blood in the left side of the heart still retain a florid appearance, the following experiment was made,

EXPERIMENT.

A Kitten was immersed in a warm medium, a little above its own temperature, and permitted to breathe under a large glass-bell for twenty-four minutes: it was then drowned in the same medium.

On opening the chest, it was found that the blood in both sides of the heart was somewhat florid, and yet this animal died, which, according to Dr. Goodwyn, should not have happened. But the cause of this

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animal's death can be readily explained; for the collapse of the lungs was here of course the same as in common drowning, and from it arose the *immediate cause* that suspends the circulation. But there was still another power operating upon this animal to destroy life; for, from the intense heat and density of the medium in which the animal was placed, it was compelled to have recourse to the process of generating cold, in order to resist the effects of this excessive stimulus; and the act of repelling heat invariably renders the powers of the animal less susceptible of action: moreover, the power of generating cold by *evaporation* was here denied. Notwithstanding, therefore, that the blood in the left side of the heart might be florid, yet the susceptibility of action being feeble, the quality of this blood was insufficient to support irritability.

It

It is worthy of remark, that in this and in every similar experiment, the heart had less action than usual, although the blood had this florid appearance; which clearly demonstrates, that much heat diminishes irritability, and this effect is probably produced by the quick action which excessive heat invariably excites, and the debility consequent on the endeavours to resist heat. Hence it follows, that although the blood might possess latent fire in abundance, and what in health when rendered sensible would have been a proper stimulus, yet, from the solids not being susceptible of action, life could not be supported. The *ultimate effect* of all violent stimuli must be that of a *sedative*; thus heat, (which is one of the most powerful stimuli in nature,) when applied to a certain degree, acts as a perpetual stimulus; but if this be carried to excess, the final effect will be extreme *de-*

bility and death. This is likewise the effect of the use of spirituous liquors, &c. a certain quantity will produce a stimulating effect, without diminishing the powers of the animal; but increase it beyond this, and *debility* will be the consequence.

It has been several times remarked, from the result of repeated experiments, that where the collapse of the lungs was removed after breathing had ceased, the circulation went on freely through the lungs, and distended the left side of the heart; but when the collapse existed, the left was not distended: which evidently proves that the *collapse of the lungs is the immediate cause of the cessation of circulation*, and not, as Dr. Goodwyn supposes, *the presence of black blood in the left side of the heart*; nor, as has been supposed by others, *from want of motion in the lungs*.

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We do not, however, consider the collapse of the lungs as forming the whole of the *proximate cause* of the *disease*; as, by the removal of the collapse, the right side of the heart is merely enabled to empty itself, and, by the *vis à tergo*, to produce an action in the left. But before the process of circulation can be completed, the animal must be provided with blood possessing an increased quantity of latent fire, as not only the left side of the heart, but the whole system, wants blood of this quality; since in the foetal circulation, the change is received before it reaches the heart, and both sides have a like stimulus. As the heart, however, in the adult must be the origin of circulation, so it is necessary that the alteration should be made immediately, before the blood enters one of these cavities; whereas, in the foetus, the heart not being the origin of circulation,

the change is given to the blood in the cells of the placenta.

There would appear a striking impropriety in saying, that *the black blood in the left side of the heart and arterial system was the proximate cause of the disease*, as *this blood* cannot be changed until it has run the course of the circulation, and returned to the lungs; and that cannot be effected without a previous removal of the obstruction formed by the *collapse*, and exciting the left to contract on its *black blood*; but even if the necessary change could be given during the existence of *collapse*, the lungs could not allow a sufficient quantity of blood to pass through them, to keep up the natural functions of the animal.

The proximate cause, therefore, of that disease produced by *drowning, hanging, and suffocation,*

suffocation, seems to be mechanical obstruction in the interior pulmonary vessels from collapse of the lungs, with a want of latent fire in the blood. Remove this collapse, and induce the necessary change on the blood, and you cure the disease.

Having thus far attempted to establish the proximate cause, we are naturally led to inquire into the usual remedies employed in this disease; and to select such as appear to be the best calculated to produce a salutary effect.

SECTION VI.

Effects of Emetics in suspended Respiration.

THE proximate cause that results from the suspension of respiration in drowning, hanging, and suffocation, we have supposed to be mechanical obstruction in the lungs, with a decrease of stimulus in the blood. The remedies employed to remove the disease are as numerous and different as the theories advanced to explain it; but, of them all, emetics, with which we begin, are perhaps the most ineffectual; their administration must even be attended with no inconsiderable injury, if had recourse to before the action of the vital functions is restored, and even then should be regulated

lated by a serious and vigilant regard to particular circumstances.

No salutary effects can be expected from vomits, but in cases where the processes of respiration and circulation have been re-established, and where inquiry informs us that the stomach has been overburdened either with food or spirituous liquors. In these cases there may be no impropriety in emptying the stomach to facilitate the descent of the diaphragm in inspiration; but to *commence* by the exhibition of emetics must be highly improper, as the action and energies of the heart, from its sympathy with the stomach, must thereby be considerably debilitated. And even admitting no such debilitating effects took place, every attempt to empty the stomach must necessarily be futile until the nervous energy be restored in a very
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sensible

fenfible degree, when they may be exhibited to more advantage.

To ascertain, however, with fome degree of precision, the effects of a powerful emetic, the following experiment was made.

EXPERIMENT.

A Puppy was drowned, and after all struggling had ceased, one drachm of emetic tartar, dissolved in two ounces of water, was injected into its stomach. The lungs were then inflated, and other means of recovery employed, until the animal made an effort to inspire; soon after which it appeared perfectly recovered.

In seven minutes from its apparent recovery it began to vomit; in twelve to
purge;

purge ; and continued frequently to vomit and purge for one hour and seventeen minutes, when it died.

On examining the stomach, it was found empty, but without the smallest appearance of inflammation.

As a temporary recovery was effected in this animal where so strong a dose of poison had been administered, and that without producing any inflammation, it was deemed requisite to introduce the same quantity of emetic tartar into the stomach of another puppy during the healthy actions of the animal, in order to determine if the effects were similar.

The experiment was made in the following manner.

EXPERIMENT.

EXPERIMENT.

Into the stomach of a Puppy of the same litter as that of the last experiment, was introduced one drachm of emetic tartar, while its natural actions remained unimpaired; in two minutes it appeared faint; in less than four vomited; in eleven purged; and in fifty-three minutes died.

The stomach, as in the last experiment, was found empty, but the *whole internal coat was nearly in a state of gangrene.*

The result of these experiments exhibits a truly remarkable circumstance, that an animal may be drowned, afterwards have poison injected into its stomach, and yet be recovered and continue to live longer than

than another of the same order and age, which had received the same quantity of poison in full health. It tends, however, to evince and ascertain one fact, that medicines introduced into the stomach do not produce the same effect when respiration and circulation are *suspended*, as when *these functions* are duly carried on: and this circumstance somewhat accounts for a phenomenon which before to me appeared extraordinary, that a recovery should sometimes be effected, even after emetics, tobacco, &c. have been administered in quantities sufficient utterly to destroy the life of the same subject if given in full health.

It may, however, at first be doubted, whether medicines that possess a sedative property, like tobacco, would not produce their greatest effect on an animal whose

powers

powers were weakest, and consequently destroy the irritability of an animal already debilitated by drowning, &c. much sooner than an animal, the vigour of whose powers remained undiminished.

To ascertain this point the following experiment was made.

EXPERIMENT.

A Puppy of about a fortnight old was drowned, and after all motion had ceased, a strong infusion of tobacco (one drachm to two ounces of boiling water, and suffered to cool) was thrown into its stomach; the usual means of recovery were then employed: in fifteen minutes it made an effort to inspire, and soon breathed tolerably well, but, in less than ten minutes after, it died.

EXPERIMENT.

EXPERIMENT.

An equal quantity of an equally strong infusion of tobacco was introduced into the stomach of another Puppy of the same age ; it immediately fell motionless on the ground, and in less than four minutes expired.

These experiments seem to prove that, whether medicines have a powerful stimulant or narcotic quality, their effects are *diminished* in proportion as the powers of the animal are *decreased*.

That medicines, however, do produce some effect before respiration is restored, has been confirmed by the following experiments.

EXPERIMENT.

EXPERIMENT.

A small Puppy was drowned, and the chest being immediately opened, the heart was observed to contract strongly. Six drachms of laudanum were thrown into its stomach, and there followed almost an instantaneous diminution of the action of the heart.

This experiment was repeated, by injecting white vitriol, emetic tartar, infusion of tobacco, &c. into the stomach, at a time when the heart was exposed to view ; and these were also found to check the force and frequency of its contractions, but particularly *tobacco*. As it therefore appears that in this disease sympathetic effects continue to arise from the application of impressions

pressions to the sympathising organs, it will at once appear obvious, that any medicine introduced into the stomach which is likely to lessen the power of the heart, must be attended with consequences highly detrimental; and that brandy, on the contrary, or any other warm cordial, which is known to increase the action of the heart, (probably in these circumstances without diminishing its power,) should only be employed.

To confirm this opinion, we proceeded to the following experiment.

EXPERIMENT.

A Dog was hanged, and the heart being exposed to view, one ounce of brandy was thrown into its stomach; the actions

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of the heart were soon quickened, and each contraction appeared more forcible than before the exhibition of this stimulus.

This experiment we frequently repeated, by increasing the quantity of spirit to six ounces and upwards; and it was found that so large a quantity quickened the actions of the heart extremely, but they were feeble and of short duration.

From these experiments, however, we can draw only this inference, that a small quantity of spirits here increased *both the power and action of the heart*, while a large quantity quickened the *action*, and *exhausted the powers*. But the analogy will not hold good with the human subject in this particular instance; for, as the stomach of the brute is not accustomed to receive so strong a stimulus as that of brandy,

brandy, its effects will be different *in degree*. Indeed, from observing that all medicines produce a less effect after respiration has ceased than during health, it is probable that six, or even eight ounces, thrown into the human stomach would not increase the action of the heart beyond its powers; and thus a cordial of some kind becomes one of the necessary remedies in this disease.

SECTION VII.

Effects of bleeding.

WE do not consider bleeding as a dangerous remedy in every case of suspended respiration from drowning, hanging, or suffocation; and, were it possible to take blood from the part where we know it superabounds, bleeding would prove one of the most immediate and efficacious means of recovery.

The right side of the heart has been found to be loaded with blood. This universally obtains in this disease; and I mentioned one or two instances in particular, where we had an opportunity of observing that the heart ceased to act from
over

over distention : but that, when relieved from a portion of its burden, its contractions were immediately renewed.

If, therefore, from the right side of the heart, while thus in a state of violent plethora, a small quantity of blood could be taken ; experiment and observation tell that its power and actions would be instantly re-invigorated.

But as this lies beyond the reach of art, the taking of blood from any other part of the body can rarely be productive of any considerable benefit, nor can it be employed with advantage but in such cases, where, from an acquaintance with the complexion and habits of the patients, we may presume that, previous to the accident or disease, a general plethora prevailed.

It may, then, be serviceable to diminish the excess of blood that loads the system; for, when the right side of the heart has got rid of its present distention, if an accumulation of blood presses in every direction on the orifices of the two cavæ, and thence on the right auricle, it must tend not a little to enfeeble or wholly destroy its action.

A certain quantity of blood is requisite to the support of the proper action of the heart; but any thing above or below the standard, will produce debility.

Bleeding, then, should be only employed where the fluids appear too abundant. When the operation is to be performed, I concur with Mr. Kite, in advising the blood to be taken rather from one of the jugulars; not, however, that we expect much
 advantage

advantage to be gained by taking blood from the head after drowning and suffocation ; but as there is here a near connection with the superior cava, the heart would sooner be relieved, than where it is drawn from the arm.

After hanging there will be a much more frequent occasion for blood-letting than after drowning or suffocation, since the cord must in some measure prevent the free return of blood by the veins ; and although we have endeavoured to prove that apoplexy can never happen, yet in these cases as there is more than the natural quantity of blood in the head, it may be of service to lessen it. But the quantity of blood in the head will much depend on the weight of the patient ; and, as bulk, weight, and general plethora, are united frequently in the same person, bleeding in such cases

is very necessary ; whereas, if the patient be tall and thin, the distance from the heart to the head considerable, and the system rather to want blood, bleeding, even after hanging, would perhaps do more mischief, by debilitating the system, than advantage could be gained, by relieving the local plethora of the head and heart ; for if the removal of the local plethora tends to increase the general debility, this last disease is more dangerous than the one we endeavour to remove.

We shall next inquire into the effects of electricity, together with those of artificial respiration, both singly and combined.

SECTION

SECTION VIII.

*Effects of Electricity and Artificial
Respiration.*

FROM electricity, as it has hitherto been recommended and employed, considerable indeed must have been the mischief that ensued. Agreeably to the method that was to direct its application, it was to be administered as a local and general stimulant, to be transmitted through every part of the body, the heart, brain, and spinal marrow ; and in all cases where electricity has been the remedy principally relied on, it seemed to supersede most of the other curative operations, but particularly that of expanding the lungs. From attending,
however,

however, to the nature of the disease produced by suspended respiration in drowning, hanging, and suffocation, it will evidently appear, that stimulating the heart, without at the same time endeavouring to remove the obstruction occasioned by a collapse of the lungs, must be one of the most ill-judged and most dangerous plans of recovery.

I repeat, there is a mechanical impediment to the passage of the blood through the small vessels of the lungs from a collapse of the air cells. This alone points out the danger of stimulating the heart, while there exists a cause that must impede its action. We are destroying its irritability, without deriving any advantage, as the circulation can go on to no effect, unless the obstruction in the lungs be first removed.

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We are, by this plan of treatment, absolutely taking away life.

Those who conceived *that the stoppage of the motion of the lungs* was the immediate cause of the cessation of the circulation, and that the lungs were not in a state of *collapse*, were led to recommend shocks of electricity to be passed through the heart, &c. without the lungs being at the same time expanded. It has been advised, that artificial respiration, as well as electricity, should be frequently *interposed*; and that, when the body is electrified, *all the other operations should cease*.

But as it has been proved, by experiment, that in this disease the lungs are in a state of *collapse*, and that the circulation is stopped from this cause, and not from the want of *motion* in the lungs; it appears that electrifying

fying the heart without expanding the lungs must be highly detrimental. Had it been ascertained that a *collapse* of the air cells existed, I am persuaded electricity applied to the heart during such a state of the lungs would never have been recommended. When electricity has been employed, the lungs have sometimes been first expanded and *collapsed*, and shocks then passed through the heart, brain, and spinal marrow ; but in this case the lungs being at the same time contracted, every electrical shock must diminish the power of the heart. Artificial respiration has also been employed after electricity ; but this second effort promises less probability of success than the first ; for the heart having before received a stimulus so great as that of electricity, it is not likely that the minor one, viz. that of the mechanical action of the lungs, should
 have

have the smallest effect. And as the heart may not naturally act more than once or twice in a minute, there are many chances to one that these contractions do not happen at the instant the obstruction is removed.

Inflating the lungs, and immediately after pressing the chest, is said to be imitating natural respiration; but it appears evident, that if the heart has not been excited to action during the expansion of the lungs, this mode of proceeding is very improper.

Neither is this process an imitation of nature; for, in health, the lungs always contain a large quantity of air, and we only expel a little, and receive in proportion. But, if all the air be discharged as soon as received, it is probable that the heart may act when
the

the lungs are contracted, and which action can produce no salutary effect.

Whatever view the operator may have, who pursues this plan of treatment; whether he supposes a change to be produced *in the blood within the auricle*, or whether he expects to propel the blood within the lungs into the left side of the heart, he will be equally disappointed. For we have observed that no change can be produced in the trunks of the pulmonary veins; and we have also found that if any alteration in the quality of the blood be made within the lungs, there is not a sufficient quantity remaining for their mechanical action to propel this blood into the left auricle.

The advantage we may expect from inflation is this; *that the right side of the heart may act at the same time the lungs are distended;*

distended; but, surely, suffering them to collapse as soon as inflated, is very unlikely to ensure success, when the heart has not been stimulated by electricity during the expansion of the lungs. Moreover, as the air can only become vitiated but by the action of the heart propelling blood into the lungs, there appears no necessity of performing a complete expiration after every inspiration, unless electricity has been at the same instant employed.

The plan of treatment likely to be useful appears to be, first, to expand *the lungs*; and, when the collapse is removed, to stimulate the heart by a shock of electricity. The heart from this stimulus may be made to contract; there is a free passage for the blood and air in the lungs to produce a change; and, if any irritability remains, the contractions of the heart will force some blood to enter the lungs.

lungs. We now perfectly collapse the lungs to convey the blood into the trunks of the pulmonary veins and left auricle. The lungs should be again immediately distended, and kept so, until another shock be passed as before.

It has been observed, that the hearts of some animals in suspended respiration have for a time the power of sending blood through the lungs, without removing the collapse; and probably in man, the heart may possess a sufficient degree of irritability to perform the same functions on being stimulated by electricity. But without considering the powerful stimulus required to effect this, and the debility which must necessarily ensue, let us inquire, what advantages can be possibly gained by propelling blood, during the collapsed state of the air cells of the lungs, from the right side of the

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the heart to the left. Allowing this could be effected, there is no air in the lungs to produce any chemical alteration on the *quality* of the blood; and if the left auricle and ventricle were in part emptied and again distended with a fluid equally foreign to the wonted stimulus, their power must every time be diminished, and consequently the right, at each contraction, require a stronger stimulus to produce the same effect; and the left finding an increasing difficulty in propelling its contents, the right would be less capable of overcoming the collapse.

This power, therefore, could only continue for a short time, and during its existence no better effect could be produced from blood passing through the lungs *without receiving a change from the air*, than when propelled by friction from any other artery into a vein.

If no electrical machine can be procured, the manner of carrying on artificial respiration should be altered; the lungs are to be expanded; and, instead of compressing the air out as soon as received, they are to be kept in a state of moderate expansion for about a minute; so that, if the heart acts during this period, there may be no obstruction to the passage of the blood.

It has been already observed that the lungs in ordinary respiration have no active power in propelling blood through them in health. But it seems in the recovery they may assist by their action; for when the heart possesses only power sufficient to send blood within the lungs, without being able to propel it to the left heart, producing an *artificial collapse* will empty the interior pulmonary vessels of the blood they have received, and excite the left auricle and
ventricle

ventricle to contraction. That the lungs will here produce this effect there can be no doubt, since we find a greater quantity of blood in them when distended than collapsed; and hence, by compressing the lungs, they must act upon all the blood they have received since the last expiration.

Care, however, should be taken, that the collapse is never suffered to *continue*; for the heart may act at this period, and *then* without effect; so that the act of inspiration in every instance should be performed immediately after the last complete expiration.

During the whole process of the treatment, from the first attempt to effect a recovery, the lungs should never be suffered to remain collapsed, that other curative means may be employed. Without

this precaution we render abortive all our endeavours to remove the cause of the disease ; for this end not previously attained, what rational hope or dependance can be placed in the application of any remedy ?

Instances of recovery have not been wanting where the lungs were not inflated ; but in such it must be attributed to an unextinguished energy of the living principle, which continued in some degree to enable the muscles of inspiration to act so as to afford admittance to a portion of air.

Does it not appear probable that the difference of success which marks the cases reported by the Humane Society, in which the same method of cure was observed, may depend in a great measure on the heart's acting, or not acting, during the *expansion* of the lungs ? Some patients were
irrecoverable

irrecoverable after respiration had been stopped for only one, two, and three minutes; whilst the recovery of others, who had remained more than half an hour under water, was effected by a similar mode of treatment.

The variation of the degrees of irritability in the same order of animals is found to be considerable; but it appears improbable, that one should be destroyed from a cause which, thirty times multiplied, is insufficient to take away life from another apparently under the same circumstances. In one case where I was present as a spectator, the body had not been long under water; yet all the endeavours to restore life proved unsuccessful. The failure of success, however, in this unfortunate case was evidently occasioned by the means and method pursued to obtain a recovery. The

smoke of tobacco blown up the rectum, frictions, and inflations of the lungs, were first employed for about ten minutes, when the two latter were suspended to allow the administration of electricity. This stimulus was applied by passing smart shocks through the heart, brain, and spinal marrow ; in fact, the whole body was electrified. The muscles through which it was conducted contracted powerfully. The shocks were repeated with sanguine hopes of success, but the contractions gradually became more feeble, and in about two hours were totally abolished.

Artificial respiration, with frictions, was again attempted, but to no effect. It is obvious that in this case a considerable degree of the vital energy was present, but absolutely destroyed by the means employed to re-establish it ; for as the proximate cause
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of the disease was not removed, every action of the heart increased the debility. But had the collapse of the lungs been taken away when the heart had been stimulated, far different indeed might have been the effects; no impediment would then have existed to the passage of the blood through the lungs, and it would have imbibed from the air its necessary portion of heat.

Inflating the lungs and electrifying the heart at the same instant, may at first view be thought difficult; but it will be found that proper instruments, constructed for the purpose, will make this an easy process.

We have observed before, that *collapsing* the lungs, as soon as distended, is not imitating natural respiration. Air blown from the mouth of another must be highly improper, as being robbed in some measure

of its purity ; and if a pair of bellows be used, it will employ three persons, one to inflate, another to secure the nostrils and mouth, and a third to press on the cricoid cartilage and chest in expiration. Nevertheless, where no other instruments are at hand, a pair of bellows may be found very useful.

But there are two disadvantages attending every instrument introduced into the nostrils ; first, the epiglottis obstructs the free passage of the air ; and part of the air, which cannot be prevented by pressing on the cricoid cartilage, will often enter the stomach ; for although pressure applied here may prevent most liquids from passing, yet so subtle a fluid as air blown with force, may make its way into the stomach. The air is not likely to produce mischief from its quality, but from the mechanical effect
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of preventing the lungs from expanding. Respiration in health is often impeded in consequence of the diaphragm in the act of inspiration being obstructed by the stomach ; and the other muscles not being able of themselves sufficiently to enlarge the chest, the right side of the heart is prevented from acting with its usual ease ; and hence a distention of the stomach from air must be attended with the same effect *.

Mr. Hunter has contrived a double pair of bellows with two valves, so that one shall perform the office of inspiration, and the other that of expiration, and these are

* From want of proper instruments I once saw the stomach and the whole intestinal canal very much distended, and a rupture, under which the patient laboured, was also considerably enlarged ; but the major part of the air may at any time be dispersed, by pressing on the abdomen.

adapted

adapted to an instrument which is to be introduced into the trachea, after bronchotomy has been performed.

This is certainly a good contrivance, but, from want of portability, they have rarely been employed.

Dr. Monro has invented an instrument to be introduced into the trachea, in the form of a common male catheter. This is mentioned by Mr. Kite ; but its use is only recommended on particular occasions : and it would seem that the insertion of this instrument into the windpipe could not answer the purpose so well as at first might be expected ; for, when introduced, the inferior orifice would be thrust against one of the sides of the trachea, and the curve pressing on the other would form an obstruction to the air.

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There also arises a great difficulty in introducing this instrument, more especially to those who have not been in the habit of employing it, as no guide is given by which we may know whether it be inserted into the larynx or pharynx; and as the aperture of the latter is so much larger than that of the former, it would rather glide into the œsophagus than into the trachea, and thus inflate the stomach instead of the lungs. The ill consequences arising from such a mistake are sufficiently obvious; and, to guard against so fatal an error, the following instrument is recommended.

As it has been deemed requisite to introduce some stimulating cordial into the stomach, a vegetable bottle (Fig. 7.) is contrived for this purpose, which is to be attached to the flexible tube, (Fig. 6. at B.) and introduced down the œsophagus; and on this
tube

tube is placed a conical piece of ivory, (cc) that is moveable, to serve as a director for the introduction of the pipe into the trachea.

The vegetable bottle being filled, the tube is to be inserted three or four inches into the œsophagus, and the conical piece of ivory is then to be carried onward by the assistance of the forefinger, so as to close the superior aperture of the œsophagus.

Having proceeded thus far, the tongue is to be brought as forward as possible, and the inferior end of the curved pipe (Fig. the 1.) passed to the farther part of the mouth, until it meets with the ivory director. The pipe being then brought a little forward, the superior extremity is to be elevated, by which means the inferior will be depressed,
and

and with ease enter the trachea: for, as the entrance of the œsophagus is situated immediately behind the larynx, and as the pipe is prevented from entering here by the ivory director, it must pass into the air-tube; so that the vegetable bottle and its appendages answer a double purpose, that of injecting fluids into the stomach, and as a guide to the introduction of the other instrument.

The * pipe for the trachea is much larger and longer than those usually employed, and the great curve is given to the superior, instead of the inferior part; from which results this advantage, that when it is fixed in the trachea, it will be nearly in a straight line with that tube; and, for the more

* It may perhaps be advisable, that the ivory director be continued in the œsophagus during the whole process of the treatment, as this will prevent air from regurgitating into the stomach.

easy

easy introduction of the instrument, the pipe is made conical, and that there may be no impediment to the passage of the air, two lateral openings are made at the inferior extremity (B).

The application of these instruments are not likely to embarrass any professional man. If, however, any impediment should prevent the insertion of the pipe into the air-tube, bronchotomy should be immediately performed; but the place, and manner of performing this operation, agreeable to the method generally recommended, do not appear the most eligible.

We are advised by authors, to begin it by a longitudinal incision, three or four rings below the cricoid cartilage, and when the trachea is met with, to divide it between the rings.

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The performance of this operation, according to this plan, can scarcely be attended with danger, when attempted by a skilful anatomist; but it may be embarrassing to a medical assistant, who is obliged hastily to perform it, when perhaps he may not perfectly recollect the situation of all the vessels; and it is to be remembered that haste is always particularly necessary on these occasions. Allowing, however, that the operation is successfully performed, great inconvenience must follow from the situation of the wound; for, in the recovery of the drowned, hanged, and suffocated, the head is, and always ought to be, kept a little elevated; the consequence of which must be, that the aperture in the trachea then becoming the most depending part, the flow of blood that follows the operation will principally enter it, and thus prevent artificial respiration from being properly

perly carried on. This is not a theory founded on hypothesis, but on facts; as I have seen two cases wherein this accident actually happened. The superficial veins of the trachea from this operation were divided and bled so considerably, as to get into the bronchia and occasion suffocation; and I have heard, from good authority, that the same effects have been known to happen in several other cases.

Another inconvenience attendant on this mode of operating is, that, from the trachea at this part being so much covered, the pipe for inflating the lungs is with difficulty secured; and should a recovery be effected, the patient must be under the necessity of keeping his chin directed constantly downward, in order to approximate the cartilages, a position that
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is not only disagreeable, but to be continued very unfavourable to the union of the parts.

In order therefore to render the operation more simple, less dangerous, and to prevent blood from entering the air-tube ; I conceive it more eligible to divide the thyroid cartilage : and that, instead of the incision first being longitudinal, and then transverse, both the integuments and cartilage should be cut through longitudinally at once.

Several are the advantages derived from this mode of operating. First, no danger can then arise from the want of anatomical knowledge. Secondly, the covering being here very superficial, little blood will be lost, and the little that does escape, cannot get into the windpipe. Thirdly, the curved pipe can be very well secured, in order to

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carry

carry on inflation and collapse. Fourthly, if our attempts to recover be successful, keeping the head naturally erect will be the best position to approximate the divided cartilage; and lastly, that the recurrent nerves and superficial veins are in no danger of being divided. The only inconvenience to be dreaded from this operation, is that of committing an injury on the sacculi laryngis, and thus to incommode the voice; but these are secured from danger, by cutting through the middle of the cartilage; and an union will be more easily effected, than if the trachea itself had alone been divided.

The surgeon standing at the right side of the patient should perform the operation by putting the integuments on the stretch with the thumb and forefinger of the left hand, a longitudinal incision is then to be made immediately over the thyroid cartilage,

lage, into which may be inserted the curved pipe that was intended to be introduced into the trachea by the mouth.

Whether this operation has or has not been performed is of little consequence to the recovery, if an instrument be introduced into the windpipe, that is connected with the other apparatus.

To the curved pipe for the trachea is to be fixed one extremity of the flexible tube, (Fig. 2. A) ; and the other end (B.) be attached to the instrument, (Fig. 3. c.) which may be fixed to the nozzle of any pair of bellows.

Every thing being prepared for inflating the lungs, one assistant is to have the direction of the bellows, and to stand at the head of the patient, whilst the other pre-

vents any air from escaping at the nostril and mouth ; or from the aperture if any has been made in the trachea.

The bellows are now to be employed, until the chest is elevated ; and the Medical Assistant, having the electrical machine prepared, is to place one director between the fourth and fifth rib of the left side, and the other between the second and third of the right ; so that the electrometer may discharge the jar, and the shock be made to pass from the apex of the left side of the heart to the basis of the right.

When the electrical stroke has been once more repeated, the assistant, who has the care of the mouth and nostrils, is now to remove his hands, and press strongly upon the chest ; the bellows are again to be immediately employed, and, another shock
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being prepared, the heart is to be thus stimulated twice or thrice, and the lungs collapsed as before.

If the heart retains any irritability, the collapse of the lungs being removed, the contractions of the heart will probably be renewed; a free passage is opened for the blood, and air admitted to give it the necessary change. But as the actions of the heart may not be sufficiently powerful to propel the blood completely through the lungs, it becomes necessary to have recourse to the artificial collapse, in order to effect this. We therefore, after having inflated the lungs, and electrified the heart, press upon the thorax, in order to expel most of the air contained in the lungs; for supposing the lungs to have received but one ounce of blood from the contraction of the heart, a certain degree of collapse will get

rid of a portion of this blood; and if the collapse be increased, the quantity of blood acted upon will also be greater. This plan of treatment appears a matter of importance, for the greater the quantity of blood sent from the right side of the heart to the left, (if at the same time it has received the wonted change from the air,) the greater undoubtedly is the probability of its exciting the left to action.

If *natural respiration* be imitated without attending to the *collapse* of the lungs, there is less probability of success, even should the heart be electrified during the expansion of the lungs. For, if the pulmonary vessels are distended with blood by the action of the right side of the heart, without producing a collapse of the lungs sufficient to enable them to act mechanically in emptying these vessels, there will arise

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nearly as much obstruction to the action of the heart as when the collapse existed; for the pulmonary vessels must then be emptied as well as distended by the action of the right side of the heart alone, which by this disease is soon rendered so enfeebled, as to be wholly inadequate to such an exertion.

By exhausting the lungs, after the heart has been made to act during inspiration, the *collapse* will in some measure supply the absence of powerful action in the right side of the heart; for all the blood the lungs have received is by that means carried to the left, by which we not only gain the advantage of sending blood which has received its due heat from the air into the left auricle and ventricle, but moreover the pulmonary vessels are again put in a fit state to receive more blood from the action

of the right, and even a feeble contraction of the heart may be capable of sending blood into the pulmonary arteries, though a more powerful one might be insufficient to propel it into the pulmonary veins and left auricle.

Mr. Field, a very ingenious mathematical instrument-maker, has invented an instrument (Fig. 4.) which may be fixed to the nozzle of a common pair of bellows for the double purpose of inflating and collapsing the lungs. (For a description of which see the explanation of the plate.) But, in order to produce this effect, it is necessary that the valve hole of the bellows be closed by the instrument (Fig. 5.) by which means all the air employed must pass through the small aperture (d. in Fig. 4.) Hence the operation of inflating and collapsing the lungs necessarily becomes a
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slow and tedious process, which may be considered as an imperfection in this instrument, particularly if the bellows to which it may happen to be fixed be not air-tight, in which case the external air will find a ready entrance, and its intention as an air-pump will be defeated.

If oxygene were at hand, there can be no doubt but that it would be far preferable to any other air for inflating the lungs; but to procure it in sufficient quantities at so critical a period is generally impracticable, we must therefore make use of atmospheric air as pure as can be obtained.

If the jar be not charged to give the electrical shock, as soon as the lungs are expanded, no mischief or inconvenience ensues; for we need only suffer a small quantity of air to escape at the mouth after
every

every inspiration, and immediately throw fresh in by the bellows; and this process is to be continued for about a minute; when, if the shock is not yet ready, we let go the mouth, and empty the lungs. The heart from this may have been irritated by the repeated inspirations, while the lungs have not been suffered to obstruct the free passage of the blood, and a fresh supply of air has been introduced to give it the necessary change; so that if the heart has acted during this period, collapsing the lungs will now convey the blood they have received into the trunks of the pulmonary veins and left auricle. This process is therefore to be pursued where any circumstance prevents the shock of electricity being given as soon as the lungs are expanded, or where no electrical machine can be procured; but, as the irritability of the heart cannot long be excited to action by
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the mere distention of the lungs, we think it of the highest importance that electricity should be employed.

It should, however, be remembered that every shock given to the heart during the collapsed state of the lungs, tends to rob it of its vital power, without promoting in the least the recovery ; and let it also be repeated, that the lungs from the beginning are never to be suffered to remain collapsed for a single minute ; as the heart may act at that very instant, and in this case without effect ; for as every contraction is an expensive operation to the heart, if it has got rid of no portion of its burden, the utmost care should be taken that the lungs be expanded at every systole of the heart ; and this can rarely happen from the usual method of inflating the lungs without at the same time stimulating the heart. When
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the heart has been once emptied, occasional shocks may be transmitted through other parts of the body (care always being taken that the heart partakes of their influence, and that the lungs be expanded); for stimulating the extremities may probably produce some degree of contraction in the arterial system; but it should be ever remembered that the heart is the origin of the circulation, and whilst other parts of the body are electrified, care should be taken that the heart at the same time partakes of the stimulus.

In order to compare the difference of the effects produced by electricity on the heart, when the lungs are collapsed, and those that result from it when the lungs are in a state of expansion, the following experiment was made.

EXPERIMENT.

E X P E R I M E N T.

A Cat was strangled, and five minutes after the last expiration the chest was opened ; the lungs were then alternately expanded and collapsed for five minutes, the heart acted rather powerfully, but no alteration could be observed in the blood of its two sides ; either as to quantity or quality.

The heart was now electrified by small shocks, during the existence of the collapse, and this was continued for five minutes, when, upon examination, it was observed that its action was evidently lessened ; the left side became rather more distended than before, but the blood was black in both auricles and ventricles.

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The lungs were now expanded, and the heart at this instant electrified: after two shocks had been given, they were collapsed, again expanded and electrified; and this process was likewise continued five minutes. On examining the heart, both sides were now found less distended, their action quickened, and the blood in the pulmonary veins, left auricle and ventricle, completely florid.

The result of this experiment not only proves the advantages of the stimulating power of electricity on the heart, beyond that of *simple inflation*; but also evinces the superiority of administering it in the distended, over the collapsed state of the lungs.

Whatever will excite the heart to expel its black blood, and supply the left side
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and the whole arterial system with blood that has imbibed its natural heat from the air, must be the means of cure the most efficacious that can be employed ; and this last experiment seems to confirm the opinion, that electrifying the heart during the expansion of the lungs, and then collapsing them, is best calculated to produce this desired effect.

With respect to the electrical machine, the more compact, and at the same time the more powerful it is, the better ; for as the quantity, necessary to be applied, must be determined by the jar and electrometer, the more speedily it can be filled the better. The size of the jar necessary for the purpose should be about thirty inches of coated surface ; and the electrometer placed a little more than one third of an inch from the jar ; the distance of which may be gradually

dually increased. It is better that the glass of the jar be thin, as the shock will then be pungent ; for if the glass be thick, the stroke will be large and dense ; and it appears probable, that the pungent stimulus would excite greater action in the heart than one that is dense, without being so liable to destroy its powers.

All that appears necessary in these cases, for the purpose of applying electricity, is, the cylinder, a conductor, jar, electrometer, wire and directors, in order to convey the shock to the particular parts we wish ; and all these may be comprised in a box of twenty inches in length, and twelve in width ; and as every medical man may have occasion to make use of electricity for other purposes, the expence will not be thrown away, even should he never meet with this most satisfactory employ of it,
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the attempting or perhaps the actual restoring of the apparently dead to life.

There appears no necessity for making use of the instrument invented by Dr. Goodwyn, for the purpose of extracting water from the lungs, as those who have recovered from drowning must all have taken in water, without its having produced any serious inconvenience; and as the extracting it would take up a considerable time, we think it better as soon as possible to proceed to the distention of the lungs.

We shall now inquire into the effects produced by the application of warmth.

SECTION IX.

Effects of Warmth.

IT has been the uniform opinion of those who have turned their attention and their pens to the subject of suspended respiration, from drowning, hanging, and suffocation, that the application of heat is absolutely necessary, and that it ought to be made with gradual, and nearly insensible increases. This idea seems to have been suggested, by attending to the good effects of warmth on torpid animals; and the manner that nature prescribed, was that of its being applied in the most gradual manner; for, where the body has been frozen, a sudden application of heat

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has been found destructive, whereas a less degree has proved beneficial.

It would be presumptuous to deny that these observations and precautions seemed well grounded. But it must, however, be confessed, that the detection of any strict similitude between the two diseases, would be attended with no small difficulty. In the one, the vital principle is attacked merely by a sedative power; in the other, it is endangered by a collapse of the lungs, which not only prevents the free passage of the blood, but at the same time deprives it of that due degree of heat, which it borrows from the air.

Dr. Goodwyn has particularly insisted on this gradual application of warmth; but his plan of treatment does not coincide with our opinion. He observes, “that, to fa-

“ your the recovery most effectually, the
 “ application of heat should be conducted
 “ on the same plan nature has pointed out
 “ for torpid animals. It should be applied
 “ very gradually and uniformly, and it
 “ may be raised to 98, but not further
 “ than 100. When the body is warmed
 “ uniformly, and the heat of the interior
 “ parts about 98, we direct our attention
 “ to the state of the thorax, and if the
 “ patient make no attempt to inspire, we
 “ proceed to inflate the lungs.” Nor does
 this practice appear to be altogether in uni-
 son with the Doctor’s own theory on the
 nature of the disease, for external warmth
 can produce no chemical change on the
 blood ; and as he asserts that the heart cannot
 act until a change has been produced, what
 great expectations can we form of its being
 attended with success. Moreover, this gra-
 dual application of heat must engross no
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inconsiderable portion of time, already too precious, before the external heat can be much increased, and the action also of the muscles of respiration could rarely be restored before that of the heart.

We also are obliged to withhold our assent from Dr. Goodwyn's opinion, where he says, that, whilst the circulation of the blood continues, the temperature of the body may be raised many degrees above the natural standard without inconvenience. To this assertion is opposed the result of Dr. Fordyce's experiments, which prove that upwards of two hundred degrees of external heat of Fahrenheit's scale could not raise the animal heat three degrees; and it may be a doubt, whether in these cases *internal* animal warmth where life is present can ever be raised to 98 or 100 by the application of external heat.

The warmth of the body in health may be decreased many degrees without much inconvenience; but never can be raised more than three or four above the natural standard, without producing pernicious effects: nature therefore has prudently provided two powers for resisting heat, while she has given only one for generating it. That warmth is essential however I admit, and that in its application it should neither be violently nor irregularly increased; but we can on no account deem it allowable to wait for any *increase* of heat in the interior parts before the lungs are inflated, as it seems impracticable to increase the living heat before this end is first accomplished.

To regulate the application of this remedy, it does not appear necessary to ascertain the degree of heat on the external surface of the body, and of the rectum, since

since we can always judge of the warmth of the atmosphere within five or six degrees; and as water, whilst in a fluid state, must have its temperature nearly equal, we need only be cautious that the warmth of the room is not at first much greater. But as it may be some satisfaction to the Surgeon to know the degree of heat remaining in the body, (since the greater the degree of heat, the greater must be the irritability,) it may not be improper or unsatisfactory to be furnished with a thermometer, and Mr. Hunter's seems the only one that is well adapted to the purpose; since ascertaining the heat of any part of the body, except in canals, cannot be of the smallest utility.

A thermometer seems also necessary for regulating the increase of heat, since our

sensations are more likely to deceive us afterwards than at first ; and it is of importance that the warmth be not very considerable : perhaps 70 degrees of Fahrenheit's scale is as much as should ever be applied, since to support any degree above this produces a waste of strength.

Warmth thus applied is certainly highly expedient, and its effects on the system are probably these, that the blood, in drowning, &c. deprived of the greater part of the latent heat it imbibes from the air, becomes insufficient to stimulate the solids ; but, by the application of sensible heat to the surface of the body, the heat of the animal is prevented from being so soon carried off ; and thus in some measure supplies the place of that latent heat which naturally is absorbed by the blood ; for, al-
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though heat be absorbed from the air in a latent form, it is given out to the system in a sensible one. Let it not, however, be understood that warmth is to effect a cure of itself; for we have repeatedly mentioned that the collapse of the lungs has caused an obstruction to the passage of the blood; and, before circulation can go on, this obstruction must be removed, and the blood furnished with its usual stimulus and change.

Various are the modes of applying heat to the body; warm bath, warm grains, &c. but these are means more easily directed than procured or put in execution; and there is only one advantage attending them, that of applying heat more universally. Even this is counterbalanced by a greater objection, as it prevents us from having recourse to frictions, and permits such a
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length of time to elapse before either warm bath or grains can be procured.

The more advisable method therefore appears to be, to place the patient on a mat-trass or bed at a proper distance from the fire, where every other operation that is thought proper can be carried on at the same time; and the readiness with which warmth can be thus applied, must certainly be a convenience.

We propose next to inquire under what circumstances frictions may be useful.

SECTION

SECTION X.

Effects of Frictions.

IT is with great propriety Mr. Kite has limited the use of frictions; at the *commencement* of the curative operations they must be productive of great mischief; for the right side of the heart being already overloaded with blood, we are by the use of frictions increasing its quantity: and it scarcely can be doubted but that this practice has contributed in many instances to frustrate the most successful treatment, by producing an over distention, and consequently indirect debility, of the right side of the heart. With a view to ascertain
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the effects of early frictions, the following experiment was made.

EXPERIMENT.

A Cat was strangled; and after it had ceased to breathe, the body and extremities were thoroughly rubbed for ten minutes, the chest was then opened. On examining the heart, the right side was found *fully* distended, and the left rather more so than usual, without any sign of action in either.

An opening was then made in the inferior cava, so as to let out a portion of blood; and the action of the right side of the heart was soon renewed.

This experiment was repeated, and it invariably resulted, that the more the right side of the heart was distended, the
weaker

weaker was its action, and, even where no action was evident during the distention, it was generally renewed by removing part of the blood from the anterior cava.

It is, however, with friction as with electricity ; if made use of at one time, it may tend to destroy life ; and, at another, it may greatly assist in the recovery.

In our survey of the common effects of suspended respiration, it was observed that the aorta and arterial system contained a quantity of blood ; this point being ascertained, and it being likewise known, that the action of the aorta and arterial system is suspended from a decrease of the due stimulus in the blood, and that the veins have little or no contractile power of their own ; when once the right side of the heart has
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been enabled to rid itself of a portion of its contents by the plan already mentioned, we should then proceed to frictions, as a substitute to the natural action of the arteries in health, viz. that of propelling the blood onward, and producing a *vis a tergo* on the blood in the veins. The right side of the heart being thus in part emptied, is again distended by the application of frictions, which should be continued as long as electricity is employed ; but when, from any cause, we are prevented from electrifying, we should be sparing and cautious in the use of frictions, lest by over distention we destroy the action of the heart. From frictions made use of as a general stimulant, little or no advantage can be expected.

The excoriations produced by the application of salt, brandy, volatile alkali, &c.
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may be exceedingly troublesome after recovery. This objection however should have but little weight were any real advantage to be derived from their use; but the application of stimuli to the eyes, noises to the ear, acrid liquors to the tongue and palate, sternutatories to the nostrils, scarifications to the skin, and the actual cautery, tend to extinguish the little that remains of animal life, rather than to rouse or re-establish it into action; for their effect on the nervous system must be similar to that of electricity when applied to the heart during the collapse of the lungs, viz. the destruction of irritability. The idea that suggested such applications must have arisen from supposing the animal powers to be only in a state of torpor, without considering that there existed a cause, without the removal of which all these attempts must not only prove fruitless and abortive, but even destructive

fructive to life, much sooner than if no remedy at all had been employed.

There appears to be an objection to the use of vitriolic acid with oil, or any application that produces an unknown and partial degree of heat. It may be preferable as a medium for friction, to make use of a little common oil or lard, which will rather prevent than occasion excoriations, at the same time that it answers every other intention ; for the principal end to be obtained by frictions is by means of their mechanical pressure ; and any medium that will facilitate this, appears preferable to those applications which stimulate and generate heat. As much warmth as is deemed requisite may be applied to the body by more certain and less disagreeable means. Nor should it be forgotten that
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the circulation even in health, is most languid at the remote parts of the body ; consequently the frictions should be chiefly applied to the upper and lower extremities, and the body should be occasionally rubbed, where it does not interfere with the electric shock.

We shall next examine into the effects of Enemas.

SECTION XI.

Effects of Enemas.

As tobacco thrown up the rectum in the form of smoke was one of the first remedies employed in suspended respiration; and as we see, to our great regret, that it is still too frequently made use of; we shall endeavour, by a few animadversions on its effects, to proscribe its continuance.

Mr. Kite, I believe, was the first who reprobated the use of tobacco; and the arguments he adduces in support of his opinion are truly ingenious.

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The history of medical errors scarce affords an instance of a more blind and obstinate prejudice, than that which still induces the Humane Society to recommend a mode of practice so obviously destructive. It is actually exhibiting a poison, that acts, as most other vegetable poisons do, by producing such an extreme degree of debility as no powers of life can support ; and there can be scarce any rashness in affirming that such quantities of tobacco have been administered in this disease in the form of smoke, as would have destroyed any man in full health. And indeed can there be any thing more evidently improper than such a practice ? We might with as much propriety recommend tobacco in syncope, or in a typhus fever, as in suspended respiration from drowning, &c. nor can there be the least doubt entertained of the effects it would produce in either of these diseases.

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When we consider the effect that a drachm of tobacco in infusion has upon the system, when given solely to produce a temporary debility in hernia, &c. one would scarcely credit that any person acquainted with this effect, could ever think of administering eight or perhaps twelve times this quantity, when the powers of life are reduced to their lowest ebb. It is really an indelible stigma on the profession, that, while we cannot but observe the deleterious tendency even of a small quantity of it, in one disease, where we wish to reduce the strength; we nevertheless employ it by wholesale in another, where scarce a spark of life remains unextinguished. With headstrong inattention we have persevered in its use, without ever asking ourselves this necessary question—What are we rationally to expect from
such

such a remedy ? This indeed, is quackery in the highest degree.

When examining the effects of medicines thrown into the stomach after respiration had ceased, it was found that their action was far less powerful than when administered in full health; and it is a fortunate circumstance indeed, that their operations are regulated by such a law; for, if medicines produced the same effect in this disease as during the unimpaired vigour of the natural functions, it may without hesitation be declared, that no one could ever have been recovered where tobacco had been employed in quantities equal to what has been recommended. Tobacco injected into the stomach will of course produce more violent effects than when thrown up the rectum; but when the quantity employed is perhaps equal to three or four

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ounces, the effects must be as violent, if not more so, than a sixteenth part injected into the stomach.

In order more accurately to determine the effects of tobacco enemas, the following experiment was made.

EXPERIMENT.

A full grown Cat was drowned, and the chest being immediately opened, the heart was observed to act strongly; six drachms of tobacco were thrown up the rectum in the form of smoke, but before the herb was half consumed, there remained scarcely any action in the heart; and after the whole had been injected, the contractions totally ceased. Mr. Kite has substituted
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in the place of tobacco, some aromatic herb; and, if we are to make use of glisters at all, herbs of this nature are certainly preferable: but no very great advantages can rationally be expected from any applications to the rectum.

If the disease is not removed by the means before laid down, we may with as much confidence expect a recovery from injecting a little warm milk and water into the stomach, as from the injection of enemas of any kind.

It should also be remembered that enemas ought to be small in bulk, in order to render them innoxious; for smoke and fluids of all kinds, when given in large quantities, will distend the intestines; the result of which will be, that their mecha-

nical effect in preventing the easy descent of the diaphragm, will necessarily be productive of mischief. Warm enemata may have the salutary effect of slightly stimulating the intestines; and the heart also, from sympathy, may possibly have its action in some small degree increased; but if tobacco be employed, the opposite effect must arise. And as sympathy is supposed to be greater between the heart and the stomach, than between the heart and intestines, it were better to inject some warm aromatic into that viscus, than into the rectum; but inflation, electricity, and frictions, ought by no means to be neglected to make room for so ineffectual a remedy.

Having examined the merits of the remedies usually employed in suspended respiration, and recommended such as are
countenanced

countenanced by inquiry and experiment, it may not be deemed unnecessary to subjoin an account of the method of conducting the treatment.

SECTION

SECTION XII.

Method of Cure.

THE plan of treatment generally to be pursued has been laid down somewhat at large in separate sections; but it may not be unsatisfactory to the practitioner, in these cases, to see the whole contracted into an abridged form, and placed in a nearer and closer point of view.

As a few minutes in this disease make a material difference as to the probability of recovery, we think it of sufficient importance to remark, that the electrical machine and the apparatus for artificial respiration, should be kept always at hand, and in readiness.

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No more spectators should be allowed to be present than are absolutely necessary; which we conceive may be eight or nine in all, including the Medical Assistants; two to have the direction of the chest, one to turn the electrical machine, one to direct the shock, four to apply the frictions, and the other to assist occasionally. This number will be sufficient for answering every purpose, and a greater number would rather embarrass, and only contribute to render the air less fit for respiration.

The body, if wet, should be gently dried with cloths, but in such a cautious manner, as to prevent the mechanical effect of the friction from propelling the blood towards the heart.

Having prepared the bed, or mattrafs,
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on a table of convenient height, the body is to be placed on it with the head a little elevated. Five or six ounces of brandy, rum, or some other warm aromatic, should be thrown into the stomach, by means of the vegetable bottle and pipe; and the ivory director passed to the farther part of the mouth, so as to close the superior aperture of the œsophagus.

If the patient seems plethoric, and more particularly if the disease has been occasioned by hanging, bleeding should be employed, and that as one of the first remedies; nor should the application of a proper degree of warmth be neglected.

The curved pipe being then introduced into the trachea, and secured by an assistant, and the flexible tube, &c. being attached, the lungs ought as soon as possible
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to be inflated ; and the electrical machine being prepared, one director is to be applied between the fourth and fifth rib of the left side, and the other between the second and third of the right ; when the electrometer is to be placed a little more than one third of an inch from the jar, and the stroke given. The electrical shock is to be repeated once or twice, and the assistant, who prevented the air from escaping by the nostrils and mouth, then should remove his hands, and press the chest, and immediately after expand the lungs, for the heart to be again stimulated.

If any impediment should prevent the introduction of the pipe down the trachea, the thyroid cartilage should be immediately divided in the manner described in Section the Eighth, and the curved pipe inserted into the trachea at this aperture.

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When the lungs have been three or four times expanded and collapsed, frictions are to be had recourse to ; these, together with the process of expanding the lungs, (and at the same time electrifying the heart,) and then again collapsing them, are to be continued four hours without intermission, unless natural respiration be restored.

In some cases where the living powers are remarkably languid, it may be advisable to continue the use of electricity, and gentle frictions, even after respiration is renewed, as there have been instances of momentary and transient recoveries : the ill success of which may be conceived to arise either from an improper use of tobacco, or the heart not possessing sufficient irritability to carry on the circulation, or from want of a supply of blood to the right side of the heart after it has
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been

been once emptied. These obstacles may probably be removed by assisting the heart and arteries to perform their respective functions, after the muscles of respiration have been stimulated to action.

If unfortunately no electrical machine be at hand, the method of performing artificial respiration should be altered. When the lungs are expanded, the assistant, who has the charge of the mouth and nostrils, suffers a small quantity of air to escape, while the other assistant continues to throw in a fresh supply : this process should be protracted for about a minute, when the hand is to be removed from the mouth, and the chest pressed, to complete the collapse. It cannot be too frequently inculcated, that the lungs are never to be suffered to *remain* collapsed ; for all our endeavours and attempts to effect a recovery, should the lungs
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be permitted to continue in that state, must ultimately prove fruitless.

We cannot better conclude the present dissertation, than by briefly recapitulating the principles and observations which form its basis and support.

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CONCLUSION.

FROM what has been observed it appears,

1. That in *ordinary* respiration and circulation the lungs are passive.

2. That the principal advantage derived from respiration, is that of its being the source of animal heat ; and this heat, by being evolved in a sensible form, keeps up the irritability of the whole animal.

3. That the blood imbibes less or more latent heat, in proportion to the degree of sensible warmth applied to the surface of the body.

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4. That

4. That the temperature of the florid blood in the left side of the heart is at first lower than that of the right; but its sensible heat soon becomes greatest.

5. That this circumstance favours the idea of heat being absorbed from the air in the act of respiration.

6. That as soon as the blood has undergone the change in the lungs, it is rendered fit to support the heat and irritability of the animal.

7. That heat is not only evolved from the blood as it passes through the capillaries, but that the same process continues throughout the whole circulation.

8. That the stimulus which excites the heart to act, is the same in all its cavities; and this principally is distention.

9. That

9. That in the foetus both sides of the heart act from the stimulus of black blood.

10. That the intent of the foetal and adult change is the same, viz. that of supporting animal heat and irritability.

11. That this change is effected in the foetus, by the blood passing through the cells of the placenta, and the vessels coming in contact with the maternal arterial blood.

12. That so much of the venous quality is imparted to the maternal from the foetal blood, and *only* so much latent fire evolved from the maternal to the foetal, as is necessary to restore the equilibrium of absolute heat.

13. That as the foetus is surrounded by the warm medium of the liquor amnii and mother, very little heat can be consumed, and therefore an absorption of heat equal to that of the adult is not necessary.

14. That the foetus possesses only one power of resisting heat, and as the heat to be imbibed by the foetal blood is always limited, and as it is always surrounded by an uniform degree of temperature, the foetus stands in no need of the power of resisting heat, or generating cold by evaporation.

15. That the foetal heart contains only a small portion of blood that has been to the placenta; and as this blood can receive only a partial change, and as even the greater part of that same blood must first pass through the capillaries before it arrives
at

at the left auricle and ventricle ; and as that which does not pass through capillaries mixes with venous blood, it follows that the left side of the foetal heart contracts from the stimulus of black blood.

16. That as all the blood which passes through the lungs must enter the left auricle, the latent heat of the foetal blood in the right side must exceed that of the left.

17. That the blood in the umbilical arteries which is to receive the change, being of the same quality with that in the left side of the heart, is an additional proof that this blood must be black.

18. That although the blood in the foetal heart and arteries be black, yet, like the blood of the adult in the right side of the

R 3 heart

heart and pulmonary artery, it must still possess a portion of latent fire, which it continues to evolve, to keep up the temperature and irritability of the parts, through which it passes.

19. That during the act of drowning the animal emits air from its lungs, and in its attempts to inspire, a small quantity of water enters the lungs and stomach.

20. That, after the last expiration, the lungs are found nearly collapsed, containing a small quantity of froth, but very little air.

21. That the quantity of blood found in the right side of the heart is nearly double that contained in the left,

22. That the blood contained in both
sides

sides of the heart is of the colour of venous blood.

23. That, whether the heart be examined during its contractions, or after they have ceased, no perceptible difference is found in the proportions of blood in the two sides of the heart.

24. That the action of the heart survives the peristaltic motion of the bowels.

25. That the vessels of the head exhibit no extravasation, nor even distention.

26. That where respiration is suspended, from ordinary hanging, the animal has the power of expelling air from its lungs.

27. That although the muscles of
R 4 expiration

expiration perform their office, no power can be applied to open the trachea to admit air.

28. That as no air can be received, the animal dies with the same collapse of the lungs from hanging as from drowning.

29. That the quantity of blood in the two sides of the heart bears nearly the same proportion in hanging as in drowning.

30. That there is very little difference in the continuance of the irritability of animals after hanging, from its continuance after drowning; but the vessels of the head are somewhat distended in the former.

31. That animals immersed in impure

air do not appear to make a full inspiration, but like animals immersed in water reject it, as soon as a sensation is produced in the trachea, which seems to make them conscious of not breathing their usual element.

32. That the muscles of expiration continue to act till they have expelled all the air from the lungs, which they have the power of acting on.

33. That the same collapse of the lungs is produced from suffocation, as from drowning or hanging; and the contents of the right side of the heart bear nearly the same proportion to those of the left.

34. That animals destroyed in impure air are sooner deprived of their irritability
than

than when respiration is suspended from drowning or hanging.

35. That animals destroyed by nitrous air soon grow stiff and inflexible, sometimes even before the heart has ceased to vibrate.

36. That the vessels of the head contain less blood after suffocation from impure air, than after hanging.

37. That in suspended respiration from any cause, the right side of the heart continues to act after the left has ceased.

38. That the cause of this difference is not that the left side of the heart is incapable of being stimulated by black blood; but from this blood being essentially different

ferent in *quality* and *quantity* from that of the right.

39. That this difference of *quality* in the blood of the left side of the heart depends on its having passed through the lungs, and imparted to them a considerable portion of its heat, without receiving a supply from respiration; while the blood of the right possesses a quantity of fire in a latent form, which it still continues to evolve.

40. That as the blood in the right side of the heart contains a portion of latent fire, while that of the left is exhausted; and as the sensible heat both of the right auricle and ventricle must consequently predominate, its irritability of course will likewise be greater.

41. That

41. That the stimulus of distention being greater in the one than in the other, will tend to produce a difference of action.

42. That as the right side of the heart possesses more irritability in this disease than the left; and as the stimulus of distention is also more powerful at the right side than at the left, its action will be continued when no effect is produced on the other.

43. That although the heart may derive its heat in health principally from the blood in the coronary vessels; yet the blood in the cavities of the heart will be also capable of evolving heat, and more especially when stagnation takes place in suspended respiration.

44. That if the right side of the heart
possessed

possessed the blood of the left, and the left the blood of the right, the degree of irritability would probably be reversed.

45. That if the right side of the heart in suspended respiration had the irritability of the left, and the left the irritability of the right, a recovery could scarcely be effected in any instance.

46. That as soon as the action of the left side of the heart is increased by the stimulus of florid blood, the right also acts more powerfully.

47. That this depends on the coronary vessels being supplied with blood, that has received a quantity of latent fire from the air, which these vessels distribute alike to the right and left side, and consequently
give

give an equal increase to the irritability of both.

48. That the heat and irritability of the heart, being then the same, the stimulus of distention will produce an equal action.

49. That the heart can be made to act after respiration has ceased, from the stimulus of electricity, while no action can be excited in the external parts from the same cause.

50. That as electricity is capable of producing action in the heart, when it has no effect on the exterior parts, and as life actually exists at this period; it might lead to most pernicious consequences to conclude that life was totally extinct, from
no

no external action being produced by electricity.

51. That as the difference of irritability in animals of the same order depends more on the specific state of the solids than on the quantity of heat evolved from the fluids, no decisive prognostic can be drawn of the presence of irritability, from the heat of the animal being above that of the atmosphere.

52. That as electricity has been found capable and incapable of producing external action during the presence of various degrees of heat, it proves that animal heat and evident irritability are by no means coequal.

53. That although no specific degree of heat will determine the presence or absence
of

of irritability, yet the greater the degree of heat, the more will be the irritability of *any particular animal*.

54. That as the heart is considered as the origin of circulation, there is a probability of recovery, so long as the heart can be made to act; although external irritability may not be manifested by the test of electricity.

55. That it will ever be better to have no criterion to judge of the absence of life, and make use of every means of recovery, in every instance, than to rely on an imperfect and hazardous prognostic.

56. That when the lungs are inflated soon after the last expiration, both sides of the heart will immediately act.

57. That

57. That this probably proceeds from the irritability of the heart being still so great as to be stimulated to action by the mechanical pressure of the lungs, as, in proportion to their expansion, will their surface press upon the two sides of the pericardium.

58. That in suspended respiration, from drowning, hanging, and suffocation, as the collapse of the lungs begins, the impediment to the passage of the blood through them commences.

59. That when the last expiration is made, the interior pulmonary vessels are collapsed, and contain but a small quantity of blood.

60. That if even a change be produced on the quality of this blood, the quantity

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is

is so small, that unless the right side of the heart be first excited to action the motion of the lungs alone will be unable to propel this blood into the left.

61. That by inflating the lungs, we cannot alter the quality of the blood in the trunks of the pulmonary veins and left auricle.

62. That the right side of the heart can propel blood to the left, immediately after the last expiration, independent of the mechanical action of the lungs.

63. That as the heart can perform this function after respiration has ceased, it is probable that the lungs have naturally no active power of propelling the blood onward.

64. That

64. That part of the black blood contained in the left auricle and ventricle in this disease, must be propelled through the system unaltered whenever a recovery is effected, and as a quantity of blood of the same quality has already passed into the arterial system, it follows that the left auricle can and does act from the stimulus of black blood.

65. That as an animal, when immersed in warm water, may be drowned with its blood somewhat florid, it necessarily furnishes an objection to the opinion, that the action of the left heart ceases from the presence of black blood.

66. That as in drowning, &c. the impetus of blood to the head is checked immediately after the obstruction to its

S 2

return

return takes place, no injury whatever can happen to the brain.

67. That if apoplexy did actually take place, we should never be able to bring about recovery after respiration had once ceased, since we frequently fail of removing common apoplexy during the existence of respiration; and as, in drowning, &c. we find no extravasation in the head, if apoplexy were to exist, it must be solely attributed to the distention of the vessels.

68. That as mere distention is capable of bringing on only a very mild species of apoplexy, which does not for many hours, and sometimes for many days, produce its fatal effect; and as, on the contrary, apparent death from drowning, hanging,
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and

and suffocation, takes place in a few minutes; it certainly follows, that this disease and apoplexy are as essentially different as any two diseases to which the human body is exposed.

69. That the immediate cause of the suspension of circulation is not *the presence of black blood in the left side of the heart*, neither is it *the want of motion in the lungs*; but *a collapse of the air cells of the lungs, which produces a mechanical obstruction to the passage of the blood in the small branches of the pulmonary vessels.*

70. That the proximate cause of the disease may be said to consist in a collapse of the lungs, producing a collapse of the pulmonary vessels, with want of latent heat in the blood, since, unless both these ef-

fects are removed, the disease will still continue.

71. That the mechanical obstruction from collapse must first be removed, before the chemical effects can take place.

72. That emetics in this disease, before the circulation is re-established, are improper.

73. That even then they should only be exhibited where the stomach is known to have been overloaded previous to the accident that produces the disease.

74. That all medicines introduced into the stomach, produce a less effect after respiration has ceased, than during the healthy actions of the animal; and that,
in

in this disease, it appears necessary to inject some warm cordial, such as brandy, &c. into the stomach.

75. That as in suspended respiration, from hanging, there is some degree of plethora in the head as well as in the right side of the heart, bleeding will then be more frequently necessary than after drowning and suffocation.

76. That the degree of plethora in the head will greatly depend on the weight and bulk of the subject.

77. That as in drowning and suffocation the plethoric state of the right side of the heart cannot be relieved by bleeding, this operation should never be performed unless it appears that there is too much blood in the system.

78. That when bleeding is judged requisite, it should be performed on the jugular veins in preference to any other.

79. That when bleeding is deemed expedient, it should be one of the first remedies employed.

80. That shocks of electricity passed through the heart, brain, and spinal marrow, without the collapse of the lungs being at the same time removed, must tend rather to destroy than restore the actions of life.

81. That imitating natural respiration without frequently producing a collapse of the lungs is improper, as the distention of the pulmonary vessels occasioned by the action of the right side of the heart
will

will form great obstruction to the passage of the blood.

82. That the uncertainty of success which has hitherto attended the cases reported by the Humane Society, has probably been in a great measure occasioned by the method of conducting the artificial respiration.

83. That the advantages to be derived from artificial respiration are, to procure a contraction of the right side of the heart when the lungs are dilated, and, by collapse, to excite the left auricle to get rid of a portion of its contents, and supply it with blood that has received its stimulus from the air.

84. That in order thoroughly to accomplish this end, we are to expand the
lungs,

lungs, and, when expanded, to stimulate the heart by a small shock of electricity; we are then to collapse them, and again to inflate.

85. That from this mode of proceeding, if any irritability remain in the heart, the right auricle and ventricle may be stimulated to act, and propel some of its blood into the lungs, where it meets with no obstruction, and air to impart to the blood its due stimulus and heat: the blood thus duly changed may, by means of the expiration, excite the left auricle to get rid of its burden, and furnish a fresh supply endued with a proper stimulus.

86. That if no electrical apparatus be in readiness, the method of conducting artificial respiration should be altered.

87. That

87. That the lungs should be distended, and, after allowing a small quantity of air to escape, the inspiration should be repeated; and this process, of suffering, after each inflation, a little air to escape, (or, in other words, imitating natural respiration,) should be continued about a minute, when the lungs are to be collapsed; so that only one complete expiration should here be made to several inspirations.

88. That the intention of this practice is, that as the heart may possibly not contract more than twice or thrice in a minute, the blood may find a free passage whenever it happens to act, and a fresh supply of air to produce the necessary change; and likewise that these several inspirations may act as a stimulus to the heart, while the collapse helps to remove the blood the lungs have received.

89. That

89. That during the whole process of the treatment the lungs should never be suffered to *remain in a collapsed state* for a single minute.

90. That electricity should never be employed on any account without a concomitant expansion of the lungs.

91. That if the heart be excited to act during the collapse of the lungs, very little more blood can pass through them than passes in the foetal circulation, and even this small portion receives no benefit from the air.

92. That the application of warmth is necessary, and that when first applied should be about six degrees above that of the open atmosphere, if this be below 70 of Fahrenheit.

93. That

93. That we are on no account, as advised by Dr. Goodwyn, to wait for any increase of animal heat before the lungs are inflated.

94. That placing the body on a mat-trass or bed, at a proper distance from the fire, is the best mode of applying warmth ; as it neither embarrasses nor prevents any other process that may be found expedient.

95. That the principal advantage to be expected from the application of warmth is, to prevent so much sensible heat being evolved from the blood, and thus in some measure supply the defect of latent heat that should have been absorbed from the air.

96. That frictions made use of as a
primary

primary remedy are highly improper, as they tend to destroy the action of the heart, by promoting an over distention of the right side.

97. That frictions should never be employed before the lungs have been several times expanded and collapsed.

98. That after the heart has been in part emptied, frictions are absolutely necessary.

99. That a little common oil or lard, as a medium for the frictions, is preferable to either salt or spirits, or any other stimulating application.

100. That the principal effect to be expected from frictions is, their mechanical

nical action in propelling blood towards the right side of the heart.

101. That tobacco in any form is highly pernicious ; and were this medicine to produce the same baneful effects in cases where respiration is suspended, as in a state of health, it is more than probable that no one could ever have been recovered where this remedy had been applied.

102. That enemas of any kind are only to be considered serviceable, in as much as they co-operate with more important remedies ; and, if employed at all, warm stimulating ones should be preferred.

103. That their bulk should be small, lest by their mechanical action they prevent the free descent of the diaphragm.

104. That

104. That inflating the lungs, electrifying the heart, collapsing the lungs, and the application of frictions, are to be continued four hours, if our endeavours be not previously crowned with success.

105. That electricity and frictions are to be continued even after respiration is restored, if the powers of life seem unequal to the task.

106. That the final intention of the whole plan of treatment is, *to imitate the natural circulation.*

DESCRIPTION OF THE PLATE.

FIG. I.

A large silver conical pipe to be introduced into the trachea, either by the mouth, or by an opening made in the thyroid cartilage. A. the inferior extremity; B. two lateral openings for the passage of the air; c. the superior end of the pipe.

FIG. II.

A short flexible tube for conveying air into the lungs. A. the inferior extremity to be attached to the superior one of the silver pipe; B. the other extremity to be connected with the contrivance (FIG. 3. at c.) or attached to Mr. Field's instrument (FIG. 4. at E)

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FIG. III.

Represents a short conical brass tube connected with a conical piece of leather, to receive the nozzle of any pair of bellows, and by means of packthread to retain it in its situation. A. the brass; B. the leather portion; C. a female screw to admit the superior extremity of the flexible tube.

FIG. IV.

Mr. Field's instrument for inflating and collapsing the lungs. A. is a conical leather tube to be attached to any pair of bellows; B B. is a brass tube; C. is a stopper to the cock, in which there are two valves opening in contrary directions; D. is an aperture through which all the air is to pass to and from the bellows, (the valve of the bellows being previously closed by another

other instrument represented in the next figure); E. the inferior extremity of the brass tube to be connected with the superior end of the flexible tube (at B.). When the stopper stands as is here represented with I (signifying Inflation) pointing to the inferior extremity of the tube, the lungs will be expanded; and when the stopper is turned half round, so that C (meaning Collapse) will be placed in the same direction, the lungs will be exhausted.

In the one instance, by the action of the bellows, air is received at the aperture D, and thrown into the lungs, but prevented from regurgitating on account of the valve: in the other, air will be received from the lungs into the bellows, and thrown out at the aperture P.

FIG. V.

Is the invention for closing the valve of any bellows. A A. is a piece of iron to be inserted into the valve-hole of any bellows, which, being placed across, prevents its being drawn out; B. is a pivot on which the iron part C C. turns; D D. is a circular flat piece of wood (lined with leather) to cover the valve-hole, with an aperture in its centre, to admit the iron C C. through it; E E. is a brass nut which is made to screw on the iron C C. to retain the piece of wood in its situation.

FIG. VI.

A flexible tube (of the same composition as flexible catheters) to be introduced into the œsophagus, for conveying spirits, &c. into the stomach. A. the bulb and inferior extremity; B. the superior; c c. is a conical piece of ivory, to be

passed a small way down the œsophagus by the forefinger, to prevent air escaping into the stomach, and as a guide for the introduction of the silver pipe into the glottis, when bronchotomy has not been performed.

FIG. VII.

Is a vegetable bottle for injecting fluids into the stomach through the flexible tube. A. the mouth of the bottle to be attached to the extremity of the flexible tube at B.

THE END.

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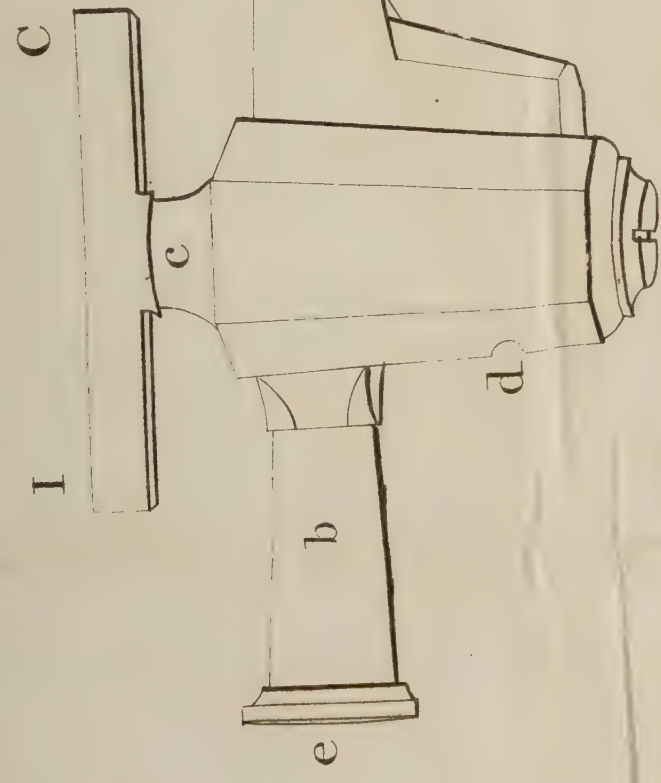


Fig. 4.



Fig. 5.

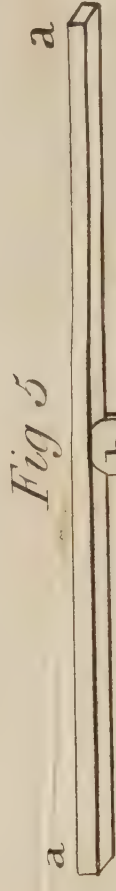


Fig. 7.

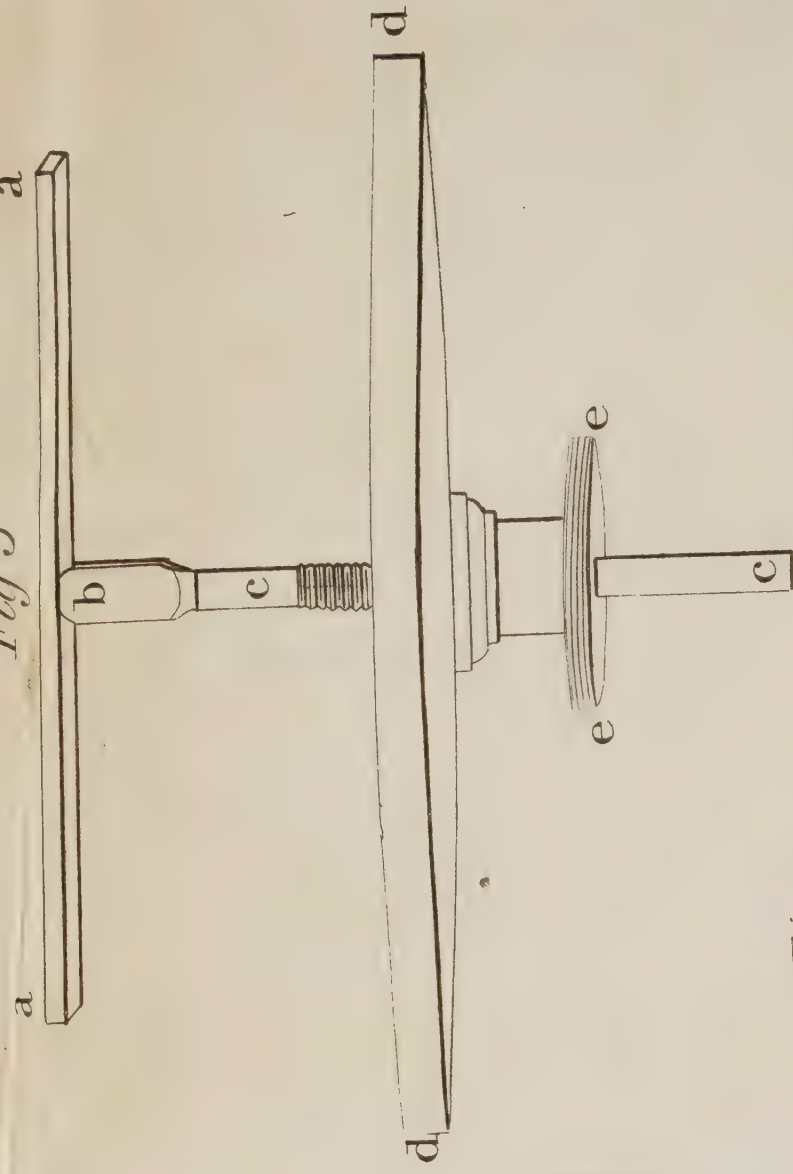


Fig. 1.

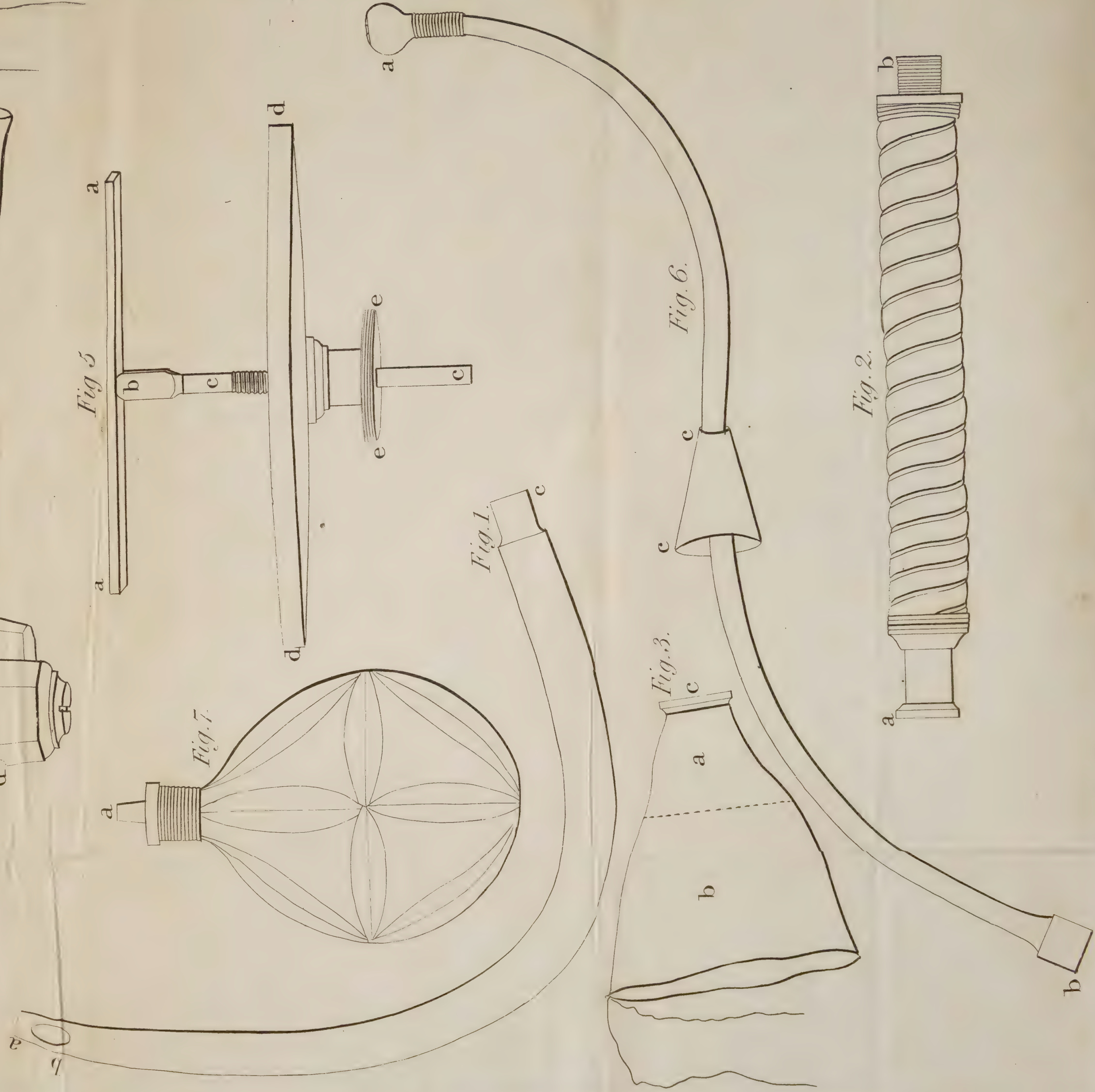


Fig. 3.

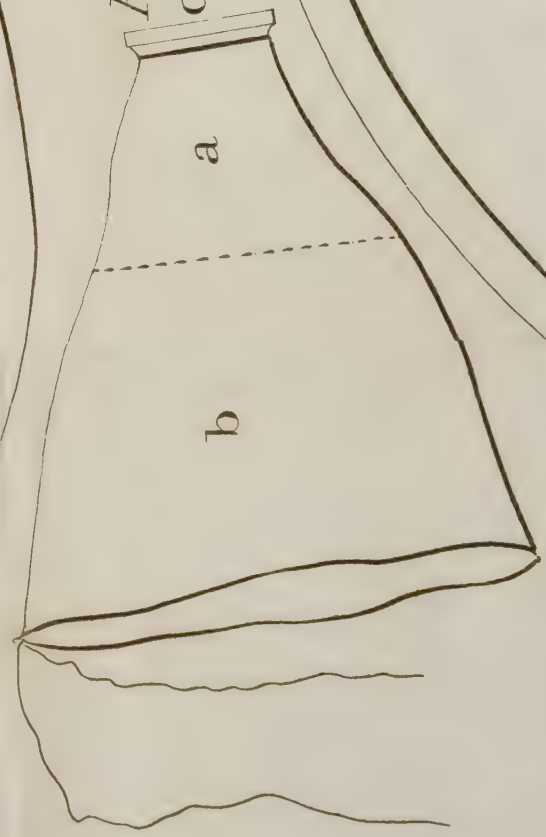


Fig. 6.



Fig. 2.

